CAMBRIAN BRACHIOPODA WITH DESCRIPTIONS OF NEW GENERA AND SPECIES.

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The following genera and subgenera are referred to in this paper, either in describing them or in referring new species to them:

Protremata: *Billingsella; Billingsella* (*Otusia*); *Nisusia; Nisusia* (*Jamesella*); *Strophomena* (*Eostrophomena*); *Orthis* (*Plectorthis*); *Orthis* (*Orusia*); *Orthis* (*Finkelnburgia*); *Protorthis; Protorthis* (*Loperia*); *Syntrophia; Polytœchia; Swantonia.*

Neotremata: *Obolella; Acrotreta; Acrothyra; Acrothele.*

Atremata: *Iphidella; Kutorgina; Rustella; Dicellomus; Curticea; Quebecia; Elkania; Schuchertina; Obolus; Obolus* (*Lingulella*); *Obolus* (*Lingulepis*); *Obolus* (*Westonia*).

This is the sixth paper resulting from the preliminary studies for the monograph on the Cambrian Brachiopoda. These notes,[a] like those that have preceded, are published in the hope that they may be of service to students prior to the appearance of the monograph.

Genus BILLINGSELLA Hall and Clarke.

1857. *Orthis* Billings, Report Geological Survey of Canada, p. 297.
1860. *Orthis* Shumard, Trans. St. Louis Acad. Sci., I, p. 627.

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[a] Note on the genus Lingulepis, Amer. Jour. Sci., 4th ser., III, 1897, pp. 404, 405.

Cambrian Brachiopoda: Genera Iphidea and Yorkia, with descriptions of new species of each, and of the genus Acrothele, Proc. U. S. Nat. Mus., XIX, 1897, pp. 707–718.

Note on the brachiopod fauna of the quartzitic pebbles of the Carboniferous conglomerates of the Narragansett Basin, Rhode Island, Amer. Jour. Sci., 4th ser., VI, 1898, pp. 327, 328.

Cambrian Brachiopoda: Obolus and Lingulella, with descriptions of new species, Proc. U. S. Nat. Mus., XXI, 1898, pp. 385–420.

Cambrian Brachiopoda: Obolella, subgenus Glyptias; Bicia; Obolus, subgenus Westonia; with descriptions of new species, Proc. U. S. Nat. Mus., XXIII, 1901, pp. 669–695.

Cambrian Brachiopoda: Acrotreta; Linnarssonella; Obolus; with descriptions of new species, Proc. U. S. Nat. Mus., XXV, 1902, pp. 577–612.

1861. *Orthisina* Billings, Geology of Vermont, II, p. 949, figs. 350–352.
1861. *Orthisina* Billings, Paleozoic Fossils, I, p. 10, figs. 11, 12.
1862. *Orthisina* Billings, Paleozoic Fossils, I, p. 138, fig. 115.
1863. *Orthis* Hall, 16th Rept. N. Y. State Cab. Nat. Hist., p. 134, pl. vi, figs. 23–27.
1863. *Orthisina* Billings, Geology of Canada, p. 284, fig. 289.
1867. *Orthisina* Hall, Trans. Albany Institute, V, p. 113.
1868. *Orthis* Hartt, Dawson's Acadian Geology, Second Edition, p. 644, fig. 233.
1882. *Orthis* Whitfield, Geology of Wisconsin, IV, p. 170, pl. i, figs. 4, 5.
1883. *Orthis* (*Orthisina?*) Hall, Report of State Geologist, N. Y., pl. xxxvii, figs. 16–19.
1884. *Orthisina* Whitfield, Bull. Am. Mus. Nat. Hist., I, p. 144, pl. xiv, fig. 6.
1884. *Orthis* Walcott, Bull. No. 10, U. S. Geol. Survey, p. 17, pl. i, figs. 1, 1a–d.
?1884. *Orthis* Walcott, Mongr. U. S. Geol. Survey, VIII, p. 22, pl. ix, figs. 8, 8a.
1886. *Orthisina* Walcott, Bull. No. 30, U. S. Geol. Survey, pp. 120–122, pl. vii, figs. 5–7.
1886. *Orthis* Matthew, Trans. Roy. Soc. of Canada, Sec. IV, p. 43, pl. v, figs. 20a–c; (?) p. 42, pl. v, figs. 18a–c.
1892. *Billingsella* Hall and Clarke, Pal. New York, VIII, Pt. 1, p. 230.
1896. *Orthis* (*Billingsella*) Sardeson, Bull. Minnesota Acad. Nat. Sci., IV, p. 96.
1897. *Billingsella* Schuchert, Bull. U. S. Geol. Survey, No. 87, p. 158.

Diagnosis.—Shell subquadrate or subsemicircular in outline. Contour unequally biconvex or plano-convex. Shell punctate. (?) Surface striate or plicate. Ventral valve with the greatest convexity; cardinal area moderately high, slightly inclined outward; delthyrium covered by a convex plate which in the type species *B. coloradoensis* has a minute perforation near the apex; teeth well developed, with dental plates extending to the bottom of the umbonal cavity and forming the sides of a small area opposite the delthyrium, where the pedicle muscle was probably attached. In the dorsal valve the cardinal area is strongly inclined, but less than 90° to the plane of the valve. The delthyrium is partially covered by a convex chilidium, or it may be altogether absent. Cardinal process single.

Type.—*Orthis coloradoensis* Shumard.

Observations.—Messrs. Hall and Clarke founded the genus on *Orthis pepina* Hall, which is a synonym of *Orthis coloradoensis* Shumard. The material from the limestones of Texas in the collections of the Survey show the form of the teeth in the ventral valve, also the deltidium and the minute perforation near its apex. Messrs. Hall and Clarke state in their diagnosis that "in rare instances [it] may be minutely perforated at the apex," but do not name the species in which the perforation occurs or where the specimens showing it are to be found. All the species known to me are biconvex or plano-convex; none are concavo-convex as defined by Messrs. Hall and Clarke.

The genus is essentially orthoid, but it differs in the presence of the arched deltidium and its general aspect.

The species may be grouped on surface characters into four sections as follows:

1. Costate:
    - *B. ? appalachia.*
    - *B. coloradoensis.*
    - *B. dice.*
    - *B. exporrecta.*
    - *B. hicksi.*
    - *B. lindstromi.*
    - *B. major.*
    - *B. obscura.*
    - *B. orientalis.*
    - *B. pumpellyi.*
    - *B. richthofeni.*
    - *B. romingeri.*
    - *B. striata.*
2. Smooth costate:
    - *B. plicatella.*
3. Smooth striate:
    - *B. highlandensis.*
4. Smooth:
    - *B. ? anomala.*
    - *B. harlanensis.*
    - *B. saffordi.*
    - *B. salemensis.*
    - *B. whitfieldi.*

Of the species referred to the genus, *Billingsella exporrecta* is one that departs from the typical species in the absence of a convex deltidium; whether this is owing to the absence of a deltidium originally or to its accidental removal from the specimens studied, is undecided.

The species referred to *Billingsella* are:

Name.	Cambrian.			Ord.
	L.	M.	U.	
1. *? anomala*, new species		x		
2. *? appalachia*, new species			x	
3. *coloradoensis* Shumard		x	x	
4. *dice*, new species				x
5. *exporrecta*		x		
exporrecta var. *rugosicostata*, new variety		x		
6. *harlanensis*, new species		x		
7. *hicksi* (Salter) Davidson		x		
8. *highlandensis* Walcott		x		
9. *lindstromi* Linnarsson		x		
10. *major*, new species			x	
11. *obscura*, new species		x		
12. *orientalis* Whitfield	x			
13. *plicatella*, new species			x	
14. *pumpellyi*, new species		x		
15. *richthofeni*, new species		x		
16. *romingeri* Barr. (Sp.)		x		
17. *saffordi*, new species		x		
18. *salemensis* Walcott	x			
19. *striata*, new species		x		
20. *whitfieldi* Walcott	x			
Olusia, new subgenus of *Billingsella*.				
1. (*Otusia*) *sandbergi* Winchell			x	

BILLINGSELLA ? ANOMALA, new species.

Shell subquadrilateral, with the dorsal valve transverse. On the ventral valve the cardinal line slopes toward the beak at an angle of from 15° to 20°, while in the dorsal valve it is nearly straight. The greatest width of the valves is about the middle of the shell. Owing to compression and consequent distortion there is considerable variation in the relative proportions of length and breadth. The cardinal angle is acute, in some instances extending out some distance beyond the widest portion of the shell, resembling in this respect the cardinal angles of some of the Stromphomenidæ. All of the specimens are so compressed in the shale that little is preserved of their natural convexity. A low, broad, mesial sinus occurs on the dorsal valve, and there is a slight flattening of the anterior central portion of the ventral valve.

The surface is marked by fine, radiating striæ that are increased in number toward the front by the addition of interstitial striæ, giving a fasciculate appearance to the surface. The radiating striæ are crossed by concentric lines of growth and fine striæ. The surface as described occurs in one specimen, all other specimens being nearly smooth. This, however, may arise from maceration and flattening out of the surface characters by compression. The interior of the shell appears to have been covered by minute punctæ.

The largest specimen of the collection has a transverse diameter of 14 mm. The average size of the ventral valve is about 8 mm. in height by 8 mm. in width.

Cardinal area about one-fifth the height of the shell. It is marked by transverse striæ of growth that cross it parallel to its base. Delthyrium rather broad. No traces of the deltidium have been observed. Cardinal area of the dorsal valve short. It is divided midway by a strong delthyrium. Nothing is known of the interior characters except the presence of short crura in the dorsal valve.

Observations.—This shell occurs quite abundantly in the very fine, buff-colored, argillaceous shales of the Coosa Valley Cambrian section. There is doubt as to its surface characters, as only one specimen found in the same beds has radiating striæ. All others appear to be nearly smooth. Its strongest character is the extension of the cardinal angle. Owing to the imperfection of the material the generic reference is doubtful.

Formation and locality.—Middle Cambrian, Coosa Valley shales. Cowan Creek section. Edwards farm, near Craigs Mountain, Cherokee County, Alabama.

BILLINGSELLA? APPALACHIA, new species.

The outline of the dorsal valve is rounded subquadrate. The height and width of the ventral valve are about the same. Dorsal valve slightly transverse.

The surface is marked by round, very fine, radiating costæ, and lines of growth, with very fine interstitial concentric striæ.

The average size of the ventral valve is about 10 mm. in height with an equal width. The largest shell observed was a ventral valve with a width of 14 mm.

Cardinal area of the ventral valve rather low. It is divided midway by a rather strong delthyrium.

Observations.—This shell in form and size is much like that of *B? anomala.* It differs in strongly marked surface characters. All the specimens are flattened in the shale by compression, and nothing is known of the interior characters.

Formation and locality.—Upper Cambrian. Rogersville shales. Four miles northeast of Rogersville, on roadside just east of Harlan's Knob, Tennessee.

BILLINGESLLA COLORADOENSIS Shumard.

Orthis coloradoensis SHUMARD, Trans. St. Louis Acad. Sci., I, 1860, p. 627.

Orthis pepina HALL, 16th Rept. N. Y. State Cab. Nat. Hist., 1863, p. 134, pl. VI, figs. 23–27.

Orthis pepina HALL, Trans. Albany Institute, V, 1867, p. 113.

Orthis pepina WHITFIELD, Geol. Wisconsin, IV, 1882, p. 170, pl. I, figs. 4, 5.

Orthis? (Orthisina?) pepina HALL, 2d Ann. Rpt. N. Y. State Geologist, 1883, pl. XXXVII, figs. 16–19.

Billingsella pepina HALL and CLARKE, Pal. New York, VIII, 1892, Pt. 1, pl. VII, figs. 18–19; pl. VIIA, figs. 7–9.

Orthis (Billingsella) pepina SARDESON, Bull. Minnesota Acad. Nat. Sci., IV, 1896, p. 96.

Billingsella coloradoensis SCHUCHERT, Bull. U. S. Geol. Sur., No. 87, 1897, p. 158.

Billingsella coloradoensis WALCOTT, Mongr. XXXII, U. S. Geol. Survey, Pt. 2, 1899, p. 450, pl. LXI, figs. 1, 1 a–d.

Shell usually transverse, but in many examples the ventral valve is longer than wide. The general outline is irregularly subquadrate to subsemicircular. On the ventral valve the hinge line slopes toward the beak at a low angle, while in the dorsal valve it is nearly straight. In some individuals the greatest width is at the hinge line. In others it is at about the middle. There is considerable variation in the relative proportions of length and breadth.

The ventral valve is slightly more convex than the dorsal. The degree of convexity of the two valves varies considerably in specimens from different localities. Some of the ventral valves from the Hudson beds at Franconia, Minnesota and the young shells from Trempealeau, Wisconsin are strongly convex.

A low, broad, mesial sinus occurs on nearly all specimens of the dorsal valve, being strongest in the young shells, and occasionally a shallow sinus is clearly defined on the ventral valve. It is quite rare to find a well-marked median fold on the ventral valve.

The surface is marked by sharply rounded, fine, radiating costæ, crossed by fine, concentric lines of growth, and very fine, slightly undulating concentric striæ. The size and sharpness of the radiating costæ vary greatly in specimens from the same bed at the typical locality in Texas. Shells occur with strong, rounded costæ, and no traces of fine, elevated lines between, while others show from one to four or more lines that start at varying distances from the beak. The imbricating lines of growth give a concentrically ridged aspect to some shells, while others are nearly smooth from beak to frontal margin. The increase in the number of costæ is by interpolation, not by bifurcation.

There is considerable variation in the size of the shell. The largest specimens from Texas have a transverse diameter of 19 mm., with a heighth of 14 mm. for the dorsal valve, and about 18 mm. for the ventral valve. Specimens of the ventral valve from the Yellowstone National Park have a height of 14 mm. with a width of 15 mm.

Cardinal area of ventral valve moderately high. It is marked by transverse striæ of growth that cross it parallel to its base and arch over the convex deltidium. The plane of the area extends backward at an angle of about 10° to the plane of the margin of the shell. The delthyrium is strong and covered by a convex deltidium, the front margin of which arches back about one-fifth the length of the delthyrium; the deltidium is marked by concentric striæ of growth and fine radiating lines and a minute perforation near its apex. The cardinal area of the dorsal valve is short as compared with the ventral valve. It extends backward at an angle of about 45° to the plane of the margin of the valve. It is divided midway by a strong delthyrium, which is covered about half its distance by a convex chilidium.

In the interior of the ventral valve the hinge teeth appear to be supported by dental plates that extend down to the bottom of the valve and bound the tripartite umbonal space opposite the delthyrium, into which the vascular sinuses extend on each side of the diductor muscle impressions, or their path of advance. The traces of the vascular system are confined to the main vascular trunks, which extend forward nearly to the front margin, where in some examples they are bifurcated. The inner branch extends in toward the median line, disappearing in the numerous radiating depressions near the margin. The lateral branches appear to connect with the peripheral canal that arches about the space, probably occupied by the ovarian areas, between itself and the main vascular trunks. The spaces for the attachment of the muscles between the main vascular trunks appear to have been quite large, extending forward to the anterior fifth of the length of the valve, but no subdivisions indicating the points of attachment of the different muscles have been detected. The pedicle muscles were probably attached to the elevated posterior portion of this central area. In some casts this posterior area is scarcely elevated above the plane of the interior. In others it is quite prominent.

In the interior of the dorsal valve the interior of the deltidial cavity supports a small, well-developed cardinal process or callosity, and a slight, narrow, median ridge occurs just in advance of the deltidial cavity. The crura are short and well defined, with relatively shallow dental sockets beside them. The cardinal process and crura vary in size and length in shells from the same locality. The only traces of the muscle scars observed show the anterior adductor impressions. The vascular trunks of the dorsal valve diverge from the central line about the center of the shell after passing around the adductor muscle impressions.

Observations.—The average size of the typical specimens from Texas is from 10 to 14 mm. in height for the ventral valve, the width being about the same. At one locality on Morgan's Creek several dorsal valves were found that have a width of 18 mm., with a height of 12 mm. This may possibly indicate a variety or distinct species, but with the material in the collection it is impossible to determine it definitely. The shells from the upper Mississippi Valley in Wisconsin and Minnesota average about the same size as the typical forms from Texas. The young shells are much more convex. The material from the Gallatin Range, Yellowstone National Park, is also much like that from Texas, but that from the limestone near Malad City, Idaho, while containing typical shells, also has specimens as large as those from Morgan's Creek, Texas.

Billingsella major differs from *B. coloradoensis* in the character of the surface striation, also in its larger size. *B. plicatella* is a unformly smaller and more convex shell, and also has distinct surface characters. The same is true of *B. striata.*

This species has a wide geographic range that extends from Texas to Missouri, Minnesota, and Wisconsin, and westward into Montana, Wyoming, and Idaho. Its vertical range in Texas is limited to the upper portion of the Middle Cambrian, and in Wisconsin and Minnesota to the St. Croix sandstone from the upper portion of the zone of the Middle Cambrian horizon nearly through the zone of the Upper Cambrian fauna; in Idaho to the Middle Cambrian; in the upper Gallatin Valley of Wyoming to the Upper Cambrian; and probably the same horizon in the Gallatin Valley below in Montana. There does not appear to be any specific variation in the shells from Texas, the upper Mississippi Valley, and the Upper Cambrian of Wyoming.

Formation and locality.—Middle and Upper Cambrian.

In Texas abundant in the limestones of the Middle Cambrian, at Packsaddle Mountain, Llano County; at Morgan's Creek, Honey Creek, and Coal Creek Canyon in Burnett County.

In Wisconsin, Middle Cambrian at Trempealeau, below the fifth trilobite bed; also in the uppermost horizon of the Upper Cambrian at that locality; Middle Cambrian zone at Hudson, at bluff near city and 4 miles from Readsburg; Osceola Mills quarry in suburbs of village near St. Croix River; Berlin; Winona; Alma; and Menominee.

In Minnesota, 4 miles southeast of Lake City; River Junction, Houston, 20 miles below Dresbach; Red Wing; Reads Landing, foot of Lake Pepin; Minneiska.

In Missouri, casts of this shell occur in the thin-bedded magnesian limestones 50 feet above the conglomerate series in St. Francois County, collected by Dr. Frank Nason; at about the same horizon in Iron County, in sec. 22, T. 35, R. 1 E., collected by Mr. D. K. Gregor.

In Montana, Spring Hill Canyon, west side of Bridger Range; east and west sides of Dry Creek above Pass Creek, Gallatin Valley; north and east Gallatin River, near Hillsdale.

In Idaho, Gallatin limestone 3 miles southeast of Malad City; also, 2 miles southeast of Malad City in limestone resting on the Flathead sandstones.

In Wyoming, Gallatin limestone on the divide at the head of Sheep Creek, Teton Range; Crowfoot section, Gallatin Range; also on the north slope of the Crowfoot Ridge on the south side of the Gallatin Valley, and on the divide between Panther Creek and the Gallatin River.

As far as known the species occurs in association with the Middle Cambrian fauna in Texas, Wisconsin, Minnesota, and Idaho. In the Teton and Gallatin Ranges, Wyoming, however, it occurs at the upper limit of the Cambrian.

BILLINGSELLA DICE, new species.

In general form and surface this shell is related to *B. romingeri.* It differs from the latter in its strong dental plates.

Formation and locality.—Lower Ordovician (?) The specimens of this shell are from a drift bowlder found near St. Albans, Vermont. The lithological characters of the matrix point to the arenaceous limestones of the Phillipsburgh formation just north of the United States and Canadian boundary as the source of the bowlder.

BILLINGSELLA EXPORRECTA Linnarsson.

Orthis exporrecta LINNARSSON, Bihang till K. Svenska Vet. Acad. Handlingar, III, 1876, No. 12; Brach. Paradoxides Beds of Sweden, p. 12, pl. II, figs. 13–19; pl. III, figs. 20, 21.

Orthis exporrecta KAYSER, Cambrische Brach. von Lian Tung, China, Richthofen, IV, 1893, p. 35.

Shell transversely subsemicircular; with the hinge line usually a little shorter than the greatest width. In a few examples it is a trifle longer; the cardinal angles are obtusely angular. The proportions between the length and breadth vary. The ventral valve is considerably more convex than the dorsal. It is evenly rounded while the dorsal valve usually has a flattening of the median area, and sometimes a slight, broad sinus. The surface is marked by numerous radiating costæ and very fine concentric striæ between the costæ, and a few visible lines of growth. The costæ are rounded, usually, but not always, broader than the interspaces and continuous from the umbo to the front and lateral margins; they appear to be quite regular, although varying much in size, and increasing somewhat irregularly by interpolation of new costæ; this usually occurs near the umbo, but may occur near the middle of the valve. The largest ventral valve in the collection has a length of 9 mm. and breadth of 11 mm. Dorsal valve, length 7 mm., breadth 10 mm. Cardinal area of ventral valve high and overhanging the posterior margin. The delthyrium is large and appears to have just a trace of a deltidium about its sides. Cardinal area of dorsal valve short and slightly inclined forward; it is divided midway by a broad delthyrium, which is divided by a strong cardinal process.

In the interior of the ventral valve, strong, main, vascular sinuses extend well forward toward the front margin; the cast of the umbonal cavity opposite the delthyrium shows a tripartite division, the center of which is the area of the path of advance of the diductor muscle impressions, and those on each side appear to be the posterior portion of the main vascular sinuses. The anterior edge of the cavity is marked by a sharp, elevated, forward arching ridge that extends to the teeth on either side; the dental plates appear to have extended to the bottom of the valve, and to have bounded the sides of the triangular umbonal cavity opposite the delthyrium.

The interiors of the dorsal valves are beautifully preserved. The cardinal process, crura, crural plates, area, anterior and posterior adductor muscle scars and vascular sinuses are very distinct; the dental sockets are shallow, but clearly shown. In one specimen there appear to be two lateral supporting septa to the thickening before the crural plates that bound the spaces occupied by the point of attachment of the diductor muscles. Doctor Linnarsson describes the cardinal process as triangular. I find it both straight, subtriangular, and triangular. A short median septum is shown in some shells, but usually the strong, slightly rounded, flattened, median ridge does not carry it.

Observations.—This is one of the most variable species of the genus both in external, and, as far as known, internal characters. It is very abundant but interiors of the ventral valve are rarely met with in good condition.

Doctor Linnarsson compares *O. exporrecta* with *Orthis hicksi* which appeared to be the most nearly related, pointing out that it differed in having fewer and coarser ribs, less pointed beak and lower area.

Formation and locality.—Middle Cambrian. Zone of *Paradoxides forchhammeri.* Linnarsson's localities are Kinnehulle, Lovened and Gudhem in Westrogothia; also at several places in Nesike; at Södra Möckleby in Öland; and in loose stones at Lillviken in Jemtland. In strata with *Agnostus laevigatus* at Carlsfors in Westrogothia, Sweden.

The specimens I have illustrated were collected by M. Schmalensee in Westrogothia.

BILLINGSELLA EXPORRECTA, var. RUGOSICOSTATA, new variety.

Orthis hicksi Linnarsson, Bihang till K. Svenska Vet. Acad. Handlingar, III, 1876, No 12; Brach. Paradoxides Beds of Sweden, p. 13, pl. III, figs. 22, 23.

Doctor Linnarsson recognized that this shell was not the same as his *Orthis exporrecta* and placed it provisionally under *Orthis hicksi*, calling attention to the fact that it was nearly related to *O. exporrecta.* With a fine series of specimens for comparison I place the shell as a variety of *B. exporrecta.* It is characterized by its strong irregular costæ. Doctor Linnarsson indicated as the most important differences; "ventral valve less convex; cast of diductor muscle scars less distinct; dorsal valve more convex and muscle scars more strongly marked; radiating ribs in the casts fewer, stronger, and more angular." All of the differences exist when we compare the extreme forms, but with a good series of specimens most of them pass gradually into forms that are typical of *B. exporrecta.*

Formation and locality.—Middle Cambrian. Zone of *Paridoxides forchhammeri.* Doctor Linnarsson found this shell at Kinnekulle and Lovened in Westrogothia and at Södra Möckleby in the island of Öland, Sweden. The specimens I have illustrated were collected by M. Schmalensee in Westrogothia.

BILLINGSELLA HARLANENSIS, new species.

The general form and convexity of this shell is similar to that of *B. plicatella.* It differs in having a nearly smooth surface marked only by fine concentric striae and a few traces of sharp radiating costæ. The interior of the ventral valve has very strong main vascular sinuses and a deep, sharply defined, tripartite umboral area opposite the delthyrium; the tripartite area is much like that in *B. coloradoensis* and *B. exporrecta.* The main vascular sinuses pass directly back across the ridge in front of the tripartite area and occupy the two lateral divisions of the area. The interior of a dorsal valve, shows an abnormal arrangement of the vascular markings and muscle scars.

Formation and locality.—Middle Cambrian. Limestone layers in Rogersville shale, 4 miles northeast of Rogersville and 11 miles northwest of Knoxville, Tennessee.

BILLINGSELLA HICKSI (~~Salter)~~(Davidson.)

Orthis hicksi (Salter MS.) DAVIDSON, Geol. Mag., V, 1868, p. 314, pl. XVI, figs. 17–19.
Orthis hicksi DAVIDSON, Brit. Foss. Brach., III, 1871, p. 230, pl. XXXIII, figs. 13–16.
Orthis hicksi KAYSER, Cambrische Brach. v. Lian Tung, China, Richthofen, IV, 1893, p. 35.

Original description.—Shell small, transversely oval; hinge-line shorter than the greatest breadth of the shell; cardinal angles rounded. Dorsal valve semicircular, moderately convex, slightly longitudinally depressed along the middle. Ventral valve convex, deeper than the opposite one. Area triangular, moderately wide; surface of valves ornamented by about ten principal, narrow, radiating ribs, with wide interspaces between each pair, in the middle of which is situated a shorter rib.

Length about 4, width 5 lines.

Obs.—*Orthis hicksi* is a scarce fossil, and very rarely found, even in a passably complete condition. It was discovered by Mr. Hicks in the middle (sandstone) beds of the Menevian group at Ninewells and Porth-y-rhaw, near St. Davids, and is the oldest species of the genus on record. It has not been hitherto found in North Wales, nor, to my knowledge, in any other locality.

This shell is most nearly related to *B. exporrecta.* It differs in its more rounded form, fewer radiating ribs and muscle area of ventral valve.

Formation and locality.—Middle Cambrian. Menevian sandstone, as stated above.

BILLINGSELLA HIGHLANDENSIS Walcott.

Orthis ? highlandensis WALCOTT, Bull. U. S. Geol. Sur. No. 30, 1886, p. 119, pl. VIII, figs. 3, 3a, 3b.
Orthis highlandensis WALCOTT, Tenth Ann. Rept. U. S. Geol. Sur., 1891, p. 612, pl. LXXII, figs. 5, 5a, 5b.

Shell transversely oval or subrotund. Front broadly rounded and nearly straight in the dorsal valve. On the ventral valve the cardinal line slopes toward the beak at an angle of about 20°, while in the dorsal valve it is less than 10°. The greatest width is about the middle of the shell. The ventral valve is moderately convex, being most elevated toward the beak, which is slightly arched over to the cardinal margin.

A dorsal valve associated in the same hand specimen of limestone is more convex than the ventral valve. The cardinal line is shorter at the greatest width of the shell. The median fold is but slightly raised above the general surface, although the front margin has a low, broad arch for the reception of the fold of the ventral valve.

There is a slight flattening in the central portion of the ventral valve that in some specimens forms a low, broad, mesial sinus toward the front margin.

The surface is marked by concentric lines of growth; otherwise it appears to be smooth. Interior casts of the valves show fine, radiating striæ toward the front. In a number of partially exfoliated shells the shell is shown to be thick and apparently solid, having been replaced by calcite.

The average sized ventral valve has a heighth of 13 mm. with a width of 16 mm. One dorsal valve is 17 mm. in width.

Cardinal area of the ventral valve unknown except that its plane extends backward at an angle of about 10° or 15° to the plane of the margin of the shell.

Casts of the interior of the ventral valve show that the dental plates extend down to the bottom of the valve, supporting distinctly defined hinge teeth. The traces of a vascular system are limited to the main vascular trunks, which extend forward well toward the front margin, very much as in *B. coloradoensis.* In one cast there is a strong furrow extending from a median furrow obliquely outward to each main vascular sinus. The median furrow extends backward to the apex of the cast that filled the space beneath the umbo and the deltidium. This portion of the cast is also marked by fine vertical venation. In another cast there is a very narrow median furrow. These median furrows probably indicate the beginning of a septum that in later forms connected the deltidium with the shell. Nothing is known of the interior of the dorsal valve.

Observations.—The original description of this species was based upon material from which the preceding description is taken, also a specimen now referred to another species in which the area is nearly perpendicular.

This species is strongly characterized by its nearly smooth surface, in having the dorsal valve more convex than the ventral, and the presence in the ventral valve of a sharp ridge beneath the umbo, indicating the beginning of the growth of a median septum.

Formation and locality.—Middle Cambrian. In the limestone with *Olenellus gilberti*, *Olenoides levis*, etc., at Pioche, and also on the west side of the Highland Range, 11 miles north of Bennett's Springs, and at the south end of the Timpahute Range, Groome District, Nevada.

BILLINGSELLA LINDSTROMI Linnarsson.

> *Orthis lindstromi* LINNARSSON, Bihang till K. Svenska Vet. Acad. Handlingar, III, 1876, No. 12; Brach. Paradoxides Beds of Sweden, p. 10, pl. I, figs. 1–8; pl. II, figs. 9–12.

The general description of *B. coloradoensis* applies to this species. The casts of the interior have the same general flatness of appearance and the exterior surfaces are not unlike. In detail the two differ materially. The radiating costæ of *B. lindstromi* are usually stronger; the umbo of the ventral valve is more prominent and the beak more incurved. The interior of the ventral valve shows shorter main vascular sinuses and more limited ovarian areas.

Doctor Linnarsson gives a fine series of illustrations of the interior of the ventral valve, which shows that there is considerable variation in the position of the vascular markings. He states that the small cardinal process appears to be bifid. I find it single in a natural cast in the limestone from Alunbruk. There is also a narrow median septum as in the dorsal valve of *B. coloradoensis.*

Doctor Linnarsson writes:

> I do not know any species with which this can be confounded. At least the adult specimens are always easily recognized. In the young ones the characters are less marked, especially in the dorsal valves. The interior and the internal cast of the ventral valve is in all stages of growth easily recognized.

Formation and locality.—Middle Cambrian. Zone of *Paradoxides forchhammeri.* Kinnekulle and Lovened in Westrogothia, Island of Öland, at Södra Möckleby and Alanbruk, Sweden. Doctor Linnarsson also found it in loose stones at Lillviken Jemtland. The specimens I have illustrated were collected by M. Schmalensee at Alanbruk.

BILLINGSELLA MAJOR, new species.

In general form and convexity this shell is related to *B. coloradoensis.* It differs from it in being larger and in having coarser radiating ribs. It is the Upper Cambrian representative of the latter species.

Formation and locality.—Upper Cambrian. Fine grained, buff colored sandstone in excavation on Wells' farm, 2 miles west of Baraboo, Wisconsin.

BILLINGSELLA OBSCURA, new species.

This species is founded on a single dorsal valve that occurs in the form of a cast in sandstone. It is transverse, width 18 mm., height 13 mm.; moderately convex with a slightly defined mesial flattening that broadens out nearly to three-fifths the width of the shell at the front margin. The surface of the cast is marked by a few faintly defined, rather broad costæ.

The shell is much like the large dorsal valves of *B. coloradoensis.* It differs in its broader frontal margin and median flattening.

Formation and locality.—Middle Cambrian. Thin bedded sandstones just above the massive Tonto sandstone near the head of Nunkoweap Valley, Grand Canyon of the Colorado, Arizona.

BILLINGSELLA ORIENTALIS Whitfield.

Orthisina orientalis WHITFIELD, Bull. Amer. Mus. Nat. Hist., I, 1884, p. 144, pl. XIV, fig. 6.

Orthisina orientalis WALCOTT, Bull. U. S. Geol. Sur., No. 30, 1886, p. 120, pl. VII, fig. 6; Tenth Ann. Rept. U. S. Geol. Sur., 1891, p. 613, pl. LXXII, fig. 8.

Billingsella orientalis HALL and CLARKE, Pal. New York, VIII, 1892. Pt. 1, p. 230.

Original description.—Shell quadrangular in outline, somewhat higher than wide, with vertical and subparallel lateral margins and broadly rounded base. Cardinal line rapidly sloping from the apex to the extremities, which are slightly rounded. Hinge line straight, as long as the greatest width of the shell. Cardinal area broad and high, divided in the middle by a triangular foramen, which is about as high as wide. Surface of the ventral valve moderately convex, marked by very fine radiating striæ and also by several concentric lines of growth. Filling of the rostral cavity and foramen large and prominent. Specimen, a cast in shale, of the ventral valve only.

Observations.—The type specimen as described above is flattened in the shale, and also appears to be compressed laterally. Uncompressed specimens referred to this species from the siliceous limestones east of Swanton show the ventral valve to have been rather strongly convex, and the dorsal valve moderately so. The outer surface as shown in the cast, indicates that it was somewhat like that of *B. coloradoensis*, but that it differs in having finer and more numerous thread-like costæ. A few traces of concentric striæ and lines of growth are preserved. The material is very unsatisfactory, but it is sufficient to indicate that the genus occurs in association with *Olenellus thompsoni* in the upper beds of the Lower Cambrian section.

Formation and locality.—Lower Cambrian. Georgia terrane. Silico-argillaceous shales: Parker's quarry, town of Georgia; and in a gray siliceous limestone lentile, 2 miles east of Swanton, Vermont.

BILLINGSELLA PLICATELLA, new species.

Shell irregularly subquadrate in outline. In the ventral valve the cardinal line slopes toward the beak at an angle of from 5° to 10°, while in the dorsal valve it is usually about 1° to 3°. The greatest width of the shell is about the middle. There is some variation in the relative proportions of length and breadth. Usually, however, the ventral valve is fully as high as wide, while in the dorsal valve it is slightly transverse. The ventral valve is rather strongly convex, the dorsal valve being less so. A low, broad, mesial sinus occurs on nearly all specimens of the dorsal valve, and sometimes a distinct sinus on the ventral valve.

The surface is marked by costæ that gives it a plicated appearance in many specimens; also concentric lines of growth and very fine, slightly undulating striæ. On some shells the costæ and surface markings have been almost entirely removed by abrasion, while in others they are clear and distinct. There is quite a wide range of variation in the strength and form of the surface markings.

When the shell is exfoliated, fine, radiating lines occur toward the front margins. The average size of the shell gives a width of about 8 mm., and in the ventral valve a nearly equal height. One specimen has a width of 11 mm.

Cardinal area well defined. It is marked by transverse striæ of growth parallel to the base. The plane of the area extends backward over the cardinal line at an angle of 10° to the plane of the margin of the shell. The delthyrium is well defined and covered by a convex deltidium, the extent of which, however, is unknown. The cardinal area of the dorsal valve is short. No details of the structure have been observed.

The cast of the interior of the ventral valve indicates short hinge teeth supported by dental plates. The markings left on the shell by the vascular system, as shown in casts, are two main vascular trunks which extend nearly in a straight line from the side of the cast of the deltidial cavity obliquely outward to the anterior fourth of the valve, where they bifurcate. The inner branch extends in toward the median line, while the lateral branches extend outward, appearing to unite with the peripheral canal. The latter arches about the space that was probably occupied by the ovarian areas, between itself and the main vascular trunks. The spaces for the attachment of the muscles between the main vascular trunks appear to have been large. No subdivision indicating the points of attachment of the different muscles have been detected. At the posterior portion of the central area there is a narrow, elevated space that posteriorly passes into the deltidial cavity. The pedicle muscles were probably attached to the front part of this elevated space. Short, radiating striæ near the margin indicate the presence of minute vascular canals.

In the interior of the dorsal valve the interior of the deltidial cavity supports a small, well-developed cardinal process or callosity. The crura are short and small, with rounded dental sockets beside them. Nothing is definitely shown of the vascular trunks or mesial impressions in the dorsal valve.

Observations.—This very pretty little species occurs in large numbers in the Gallatin limestone, Montana. In form it is not unlike the convex forms that have been referred to *B. coloradoensis* from Trempealeau, Wisconsin. It differs from the latter in having strongly marked surface plications and a narrower deltidium. From *B. striata* it differs in surface characters; also in having a more convex dorsal valve.

Formation and localities.—Upper Cambrian. Gallatin limestone, east side of Dry Creek, above Pass Creek, Gallatin Valley; west side of Dry Creek not far from mouth of Pass Creek; north of East Gallatin River near Hillsdale; on ridge between Churn and Cottonwood canyons, west side of Bridger Range, Montana.

All representatives of this species were collected by Dr. A. C. Peale. of the Hayden survey, except some obscure specimens I found at the base of the limestone above the Flathead shales 6 miles north of York, in the Big Belt Mountains, Montana.

BILLINGSELLA PUMPELLYI, new species.

General outline subsemicircular, greatest width at the hinge line or a little in advance of it; considerable variation exists in the relative proportions of length and width; a ventral valve 8 mm. long has a width of 9 mm.; the dorsal valve is more transverse, length 5.5 mm., width 8 mm. The ventral valve is strongly convex with the umbo arching over to the apex, which is a little above the plane of the margins of the valve; a very slight median fold occurs near the front margin; dorsal valve slightly convex and with a shallow median sinus.

The surface is marked by low, sharp ribs with wide interspaces, on which fine radiating striæ occur. Concentric lines and striæ of growth cross the radiating striæ and ribs.

The characters of the cardinal areas of the valves are almost unknown; that of the ventral valve appears to have been of moderate height and inclined but a little from the plane of the valve; one interior of the dorsal valve shows a low cardinal process. The cast of the interior of the ventral valve shows the presence of a tripartite elevated umbonal space into which the strong main vascular sinuses extend, as in *Billingsella coloradoensis;* the sinuses extend forward nearly to the front margin of the valve. Of the interior of the dorsal valve only the presence of a strong median ridge is known.

Observations.—This species is one of the costate forms of the type of *B. coloradoensis* and *B. romingeri.* It differs from them in surface characters. It may be considered the trans-Pacific representative of *B. coloradoensis.*

The specific name is given in recognition of the work of Raphael Pumpelly upon the geology of China.

Formation and locality.—Middle Cambrian. Chao Mi Tien limestone. Three miles southwest of Yen Chuang, also Chao Mi Tien, Shantung, China. Collected by Eliot Blackwelder and Bailey Willis, of the Carnegie Institution Expedition, 1903.

BILLINGSELLA RICHTHOFENI, new species.

This species is represented by two specimens of the exterior of the ventral valve. They vary from 4 to 5 mm. in length and width, the length and width being about the same. The outer surface is marked by fine, obscure, radiating ribs and very fine concentric striæ. The general form is much like that of the ventral valve of *Billingsella pumpellyi.* It differs from the latter in having a shorter hinge line in proportion to the width, the more uniform and stronger convexity of the surface, and the more elevated apex.

The species is named after Dr. Ferdinand von Richthofen.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Two and one-half miles south of Yen Chuang, Shantung, China.

Collection of Mr. Eliot Blackwelder, Carnegie Institution Expedition to China.

BILLINGSELLA ROMINGERI Barr.

Orthis romingeri BARR, Ueber die Brachiopoden der Sil. Schi. Böhmen, II, Abth. Haidingers Naturw. Abhandl., II, 1848, pp. 203, pl. XVII, fig. 8.

Orthis romingeri BARR, Syst. Sil. Böheme., V, 1879, pl. LXII, figs. 1–4.

Orthis romingeri POMPECKJ, Die Fauna des Cambrium von Tejřovic und Skrej in Böhmen, Jahrbuch der k. k. geolog. Reichsanstalt, 1895, XLV, 1896, Pts. 2 and 3, pp. 513, pl. XV, figs. 1–5a.

Shell transverse, the general outline being irregularly subquadrate to subsemicircular. On the ventral valve the cardinal line slopes toward the beak at a low angle, while in the dorsal valve it is approximately straight. In some shells the greatest width is at the hinge line, while in others it is about the middle of the valve. There is considerable variation in length and breadth.

The ventral valve is rather strongly convex and the dorsal valve moderately so. The dorsal valve is slightly flattened from the umbo to the frontal margin, the flattening sometimes taking the form of a shallow depression. A low, broad, mesial sinus occurs on the dorsal valve that is strongly marked in the young shells. The surface is marked by rounded, bifurcating, radiating costæ, crossed by concentric lines of growth and undulating concentric striæ. The radiating costæ vary in size and character in specimens from the same locality. In some specimens they are very regular, while in others there will be wider interspaces or a variation in the manner of interpolation. The ridges of growth also vary in strength and elevation in different shells.

The largest shell in quite a large quantity of material has a height in the ventral valve of 13 mm. and in the dorsal valve of 10 mm., with a width of 15 mm. Cardinal area of ventral valve rather high and slightly incurved; it is marked by transverse striæ of growth that cross it parallel to its base; the plane of the area extends backward at an angle of about 10° to the plane of the margin of the shell; the delthyrium is rather large; a deltidium is indicated in some of the casts, but none of the specimens show it clearly. The cardinal area of the dorsal valve is about one-half the length of that of the ventral valve. It extends backward at an angle of more than 45° to the plane of the margin of the valve, and is divided midway by a strong delthyrium, which is covered, for a part of its distance at least, by a convex chilidium.

The traces of the vascular system in the ventral valves are seen in the main vascular trunks which extend well forward toward the front margin, where they appear to bifurcate, the inner branch extending toward the median line, and the lateral branches apparently connect-ing with the peripheral canal that arches backward about the ovarian areas between it and the main vascular trunks. No points of attachment of the various muscles in the ventral valve have been observed. The area in which the diductor muscles are attached is well marked in some specimens, and the cardinal process of the dorsal valve in others. There are also shown in the dorsal valve the anterior adductor impressions. In the interior of the dorsal valve the deltidial cavity separates a small cardinal process or callosity, which is straight or subtriangular. The crura are relatively long and very prominent, with distinctly defined dental sockets beside them.

Observations.—This species was well illustrated by M. Barrand. In the material of the collections of the Museum of Comparative Zoology, Cambridge, Massachusetts, there is a fine series illustrating the interior of the ventral and dorsal valves, that through the kindness of Dr. Alexander Agassiz I was enabled to study.

The species in its external and internal shape varies so decidedly from all described forms that it is not necessary to point out differences between them.

Formation and locality.—Middle Cambrian. Argillites and fine-grained sandstone near Skrej, Bohemia.

BILLINGSELLA SAFFORDI, new species.

General outline of ventral valve subsemicircular and of dorsal valve transversely broad oval; greatest width of valves at about the center; hinge line straight and a little shorter than the greatest width of the shell. A typical ventral valve has a length of 9 mm., width 9 mm. Dorsal valve, length 10 mm., width 12 mm. Biconvex, the ventral valve being more elevated at the umbo than the dorsal. Surface as far as known smooth or marked by concentric striæ and lines of growth.

Ventral valve with umbo curving over and terminating in the small apex that incurves a little over the area; area about one-half the elevation of the valve, a broad delthyrium is partially covered by a convex deltidium; casts of the interior indicate a low, tripartite pseudospondylium, and one cast shows strong main vascular sinuses extending from the lateral divisions of the pseudospondylium nearly to the front margin. Dorsal valve with low area and small pseudocruralium; the casts are too imperfect to show any other details.

Observations.—This species occurs in the same region as *B. harlanensis* and also has a smooth shell; it differs in being of equal length and breadth and in having less strongly marked interior characters.

The species is named after Prof. James M. Safford, former State geologist of Tennessee.

Formation and locality.—Middle Cambrian. Rome sandstone, along First Creek Gap, 4 miles north-northeast of Knoxville, Tennessee.

BILLINGSELLA SALEMENSIS Walcott.

Orthis salemensis WALCOTT, Amer. Jour. Sci., 3d ser., XXXIV, 1887, p. 190, pl. I, figs. 17, 17a; Tenth Ann. Rept. U. S. Geol. Sur., p. 612, pl. LXXII; figs. 6, 6a.

Shell about the average size of the Cambrian species of the genus. Transversely subquadrilateral; front broadly rounded and slightly sinuate midway; hinge line as long as the greatest width of the shell.

Ventral valve convex, most elevated about one-fourth the distance from the beak to the anterior margin; beak small and incurved to the margin of the medium-sized area; the surface of the area and the foramen have not been observed; mesial sinus broad and shallow, marked by a low median rib and laterally by two costæ on each side, a third appearing just outside the sinus.

The dorsal valve, associated in the same hand specimen of limestone, is slightly more convex; frontal margin with a rather deep sinuosity to receive the projection of the ventral valve; median fold broad and but slightly elevated, marked by two or three low costæ; the beak appears in the broken specimen in the collection to be scarcely elevated above the surface of the shell, and to terminate at the cardinal margin; area unknown.

The surface of both valves is marked by fine concentric lines of growth, and low, rounded costæ, varying in number from six to seven.

In the broad costæ and the general aspect of the shell this species is unlike any known to me from the Cambrian, with the exception of *B. whitfieldi*, from which, however, it differs in strength and character of costæ and outline of valves.

Formation and localities.—Lower Cambrian; limestone interbedded in the shaly slates 1½ miles south of Salem; 1 mile south of Shushan, and near Rock Hill school house (No. 8), Greenwich, Washington County; bedded limestone of Olenellus zone on north side of Beman Park, Troy, New York. It is also present in limestone bowlders of the Cambrian conglomerate at Metis, on the St. Lawrence, below Quebec. *Olenellus* sp. *Hyolithellus micans*, etc., occur in association with it.

Cat. U. S. Nat. Mus., No. 17443.

BILLINGSELLA STRIATA, new species.

The form of the ventral valve of this species is much like that of *B. plicatella*. It differs in having a finely striated outer surface, and in the strong development of the main vascular sinuses and the broader deltidial cavity. The only two specimens of the dorsal valve are nearly flat.

Formation and locality.—Middle Cambrian? The character of the matrix indicates that the specimen came from the Flathead formation. Forks of Pole Creek above Cherry Creek Valley, Madison County, Montana.

BILLINGSELLA WHITFIELDI Walcott.

Kutorgina whitfieldi WALCOTT, Mong. U. S. Geol. Sur., VIII, 1884, p. 18, pl. IX, figs. 4, 4a.

Billingsella whitfieldi SCHUCHERT, Bull. U. S. Geol. Sur. No. 87, 1897, p. 159.

Shell convex, hinge line straight and a little less than the greatest width of the shell, sides rounding regularly into the slightly convex frontal margin.

Ventral valve quite convex, elevated along the center to form a flat depressed fold, and sloping quite rapidly from this to the lateral and cardinal margins; median elevation with about five rather faintly defined, simple plications, that reach up to the higher portion of the valve; beak small, a little depressed, and rising above the area; cardinal margins straight and diverging from the beak at an obtuse angle; character of area unknown.

Dorsal valve depressed convex, with a rather wide, shallow, median depression, and two short plications on each side of it toward the front, which are obsolete in some of the specimens; the area between the cardinal edges and the elevation of the sides of the mesial depression is depressed and corresponds to the flattened lateral slope of the ventral valve.

Surface marked by fine, very clearly defined concentric striæ that are crowded together into narrow ridges and are subparallel to the front and lateral margins of the shell.

B. whitfieldi belongs with the group of species including *B. salemensis* or shells with coarse plications and very fine concentric striæ. The latter species occurs with the Olenellus fauna in eastern New York, and *B. whitfieldi* in the Middle Cambrian of Central Nevada.

Formation and locality.—Lower Cambrian. Prospect Mountain group, beneath the Secret Canyon shale, on the west side of Secret Canyon, Eureka District, Nevada.

OTUSIA, new subgenus of BILLINGSELLA.

This name is proposed to include *Orthis sandbergi* of N. H. Winchell, which is the only species known at present. The subgeneric and species characters are included in the description of the species.

BILLINGSELLA (OTUSIA) SANDBERGI Winchell.

Orthis sandbergi N. H. WINCHELL, Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minnesota, 1886, p. 318, pl. II, figs. 8, 9.

Orthis ? sandbergi WALCOTT, Mong. XXXII, U. S. Geol. Sur., 1899, p. 452, pl. LXI, figs. 2, 2a–d.

Shell small, transverse, subquadrate in outline, exclusive of the acute cardinal extremities. Valves slightly convex, with a straight hinge line longer than the greatest width of the shell; cardinal area narrow but well developed on each valve and divided by a rather large open delthyrium.

The ventral valve slightly flattened at the cardinal extremities, rising toward the center with a convex triangular swelling, broadening from the narrow beak to the front; beak small, rounded, and extending slightly beyond the hinge line. Dorsal valve flattened at the cardinal extremities, with well-marked rounded ridges rising between them, and a rather broad, well-defined median sinus; beak very small, slightly encroaching upon the hinge line.

Surface marked by fine, regular, radiating striæ, between which one or more faint intermediate striæ are sometimes visible; under favorable conditions very fine concentric striæ can be seen, and there are also usually present more or less distinctly marked lines of growth.

Very little is known of the interior of the ventral valve. Two fragments of the posterior portion show a broad delthyrium, strong teeth, and a broad umbonal cavity opposite the delthyrium. In the ventral valve the area is narrow and divided by a broad delthyrium, which has a strong cardinal process that extends forward nearly three times the length of the area. Anteriorly, it rests on a broad ridge that extends forward, gradually broadening out and disappearing at the anterior margin of the shell.

In my former description[a] I stated that "the generic character of this species has not been fully ascertained, but the material from the Yellowstone National Park and specimens from the typical locality at Red Wing, Minnesota, lead me to think that this can not be referred to the genus *Billingsella*. It appears to be an *Orthis* of the *Plectorthis* group of Hall and Clarke." A more thorough study of this species and the forms referred to *Billingsella* leads me to place it in a subgenus of *Billingsella* on account of its surface character, the character of the delthyrium in the two valves, and the strong cardinal process and median ridge in the dorsal valve.

A comparison of the specimens of this species from a typical locality at Red Wing, Minnesota, with those from the Yellowstone National Park, shows the two shells to be specifically identical as far as the comparison of casts in sandstone can be made with well-preserved shells on the surface of limestone. This is the only species of this type known to me in the Cambrian fauna.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Red Wing, Minnesota. Upper Gallatin limestone, north side of Elk Pass, between Buffalo and Slough Creeks, Yellowstone National Park, Montana.

NISUSIA, new genus.

Form subquadrate to transversely semioval. Shell substance fibrous; surface with narrow, radiating ribs that support irregularly distributed spines on their crests.

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[a] Mong. XXXII, U. S. Geol. Sur., p. 453.

Ventral valve elevated and usually much more convex than the dorsal, and in most species a mesial sinus appears on it. Area high, vertical, or inclined backward; delthyrium large and partially closed with a convex deltidium; teeth strong and supported by dental plates that extend outward, also inward forming on the inside a shallow spondylium. Dorsal valve moderately convex with only a trace of a median elevation; usually the surface is convex, but it may be slightly concave from the umbo to the margins; crura well developed with the crural plates extended so as to form a shallow cruralium. No traces of a cardinal process have been observed in the dorsal valve.

Type of genus.—Orthis festinata Billings. Lower Cambrian. Only one other species is now known, *Nisusia alberta* from the Middle Cambrian horizon.

The species referred to *Nisusia* and the subgenus *Jamesella* are:

Name.	Cambrian.		
	L.	M.	U.
1. *alberta*, new species	......	x	......
2. *festinata* Billings	x	......	......
festinata var. *transversa* Walcott	x	......	......
Jamesella, new subgenus of *Nisusia*.			
1. (*Jamesella*) *amii*, new species	x	......	......
2. (J.) *argenta*, new species	x	......	......
3. (J.) *erecta*, new specics	......	x	......
4. (J.) *kuthani* Pompeckj	x	......	......
5. (J.) *perpasta* Pompeckj	x	......	......
perpasta var. *macra* Pompeckj	x	......	......
perpasta var. *subquadrata* Pompeckj	x	......	......
6. (J.) *utahensis*, new species	......	x	......
7. (J.) species undetermined	x	......	......

NISUSIA ALBERTA Walcott.

Orthisina alberta Walcott, Proc. U. S. Nat. Museum, XI, 1888, p. 442.

Billingsella alberta Schuchert, Bull. U. S. Geol. Sur. No. 87, 1897, p. 158.

Orthisina alberta Matthew, Trans. Roy. Soc. Canada (ser. 2), VII, 1902, Sec. 4, p. 109.

Shell transversely suboval, front broadly rounded; the straight hinge line is shorter than the full width of the valves. Surface of shell with numerous radiating ribs that increase by interpolation; on a shell 19 mm. in width there are four ribs near the front margin in a distance of 3 mm.; the ribs are rather narrow and sharp crested, the interspaces being wider than the ribs. A cast of the outer surface of a shell in silicious shales shows numerous strong spines irregularly distributed on the ribs very much as in *N. festinata*.

Ventral valve elevated at the umbo and apex in some shells, convex and rounded over toward the area in others; area varying in height in different shells, usually elevated and overhanging the hinge line, it is divided by a strong delthyrium that is covered by a convex deltidium of varying length, arched at its front margin and divided by longitudinal lines into three parts.

Dorsal valve gently convex; area low and a little inclined over the hinge line; delthyrium broad with a narrow chilidium. Casts of the interior show a broad, well defined pseudocruralium, and just in advance of it the adductor muscle scars.

Observations.—This species recalls at once *N. festinata* by its elevated ventral valve and spinose surface; it differs from it by its transversely suboval outline, large umbonal muscle cavity (pseudocruralium) in the dorsal valve, and sharp-crested ribs. *N.* (*Jamesella*) *perpasta* has the general form and surface characters of this species. A marked difference in appearance is caused by *N. alberta* occurring in a silicious shaly matrix and *N.* (*Jamesella*) *perpasta* as casts in a quartzitic sandstone and the strong surface spines of *N. alberta* are sparingly represented on the latter.

Formation and locality.—Middle Cambrian. Mount Stephen shale, 2,000 feet above Olenellus zone, Mount Stephen section. British Columbia.

The original specimens were from the collection of Dr. Karl Rominger. I now have material belonging to the Geological Survey of Canada, United States National Museum, and Mr. Byron E. Walker, of Toronto, Canada.

NISUSIA FESTINATA Billings.

Orthisina festinata BILLINGS, Geol. Sur. Canada, Pal. Foss., I, 1861, p. 10, figs. 11, 12; Geol. Vermont, II, 1862, p. 949, figs. 350-352; American Jour. Sci., 2d ser., XXXIII, 1863, p. 105; Geol. Canada, p. 284, fig. 289.

Orthisina festinata WALCOTT, Bull. U. S. Geol. Sur. No. 30, 1886, p. 120, pl. VII, figs. 7, 7a, 7b; Tenth Ann. Rept. U. S. Geol. Sur. 1891, p. 613, pl. LXXII, figs. 7, 7a, 7b.

Billingsella festinata HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, p. 230.

General form subquadrate to transversely semioval, with the cardinal extremities subacute to obtusely angular. Hinge line straight, usually equal to or greater in length than the width of the body of the shell. Shell substance fibrous.

Surface with narrow, rounded, radiating ribs, that increase by both bifurcation and interpolation; the ribs are roughened by concentric lines and ridges of growth that arch about the base of strong, acute spines; the spines are located on the ribs, usually just back of a ridge of growth; they are in more or less irregular, concentric rows toward the front of the shell, but on the central portions they may be scattered without any system of arrangement; each spine is larger at the base, tapering rapidly, and curving gradually backward at about one-half its length.

The ventral valve is more or less elevated at the umbo and apex; in some examples it is subpyramidal, where the height is to the length as 3 to 6, and width 9 mm.; in other shells the proportion is 4 to 11, and width 17 mm.; the slopes from the apex to the margins are nearly straight or slightly convex; the form of the umbo and apex varies from a broad rounded umbo, terminating in a minute beak curving over the area, to an erect, vertical, more or less rounded apex, with a broad base rising abruptly from the elevated umbo; a shallow, rounded, median sinus occurs on most individuals, but it is sometimes absent. Area high, and crossed by transverse lines of growth; it is usually inclined over the hinge line, but it may be vertical or inclined forward; it is divided by a strong delthyrium, which is covered by a convex deltidium that the author of the species, Doctor Billings, describes as perforate at the apex.[a]

I have not been able to verify this in a large collection of material from various localities; casts of the interior of the extended beak indicate but do not prove that there was a perforation; the front edge of the deltidium is arched so as to leave a space of variable height between it and the plane of the hinge line; in three examples the area is divided into three parts by longitudinal lines, two of the lines bound the delthyrium, and one on each side corresponds in position to the "flexure" lines in *Obolus* and *Hipparionyx*. A cast of the interior of a low ventral valve shows a broad delthyrium, strong teeth, and supporting dental plates, which are produced on the inside, so as to form a short, elevated base (pseudospondylium), probably for the adductor muscles, and on the outside the plates are continued partially about the space occupied by the points of attachment of the diductor muscles.

The dorsal valve is moderately convex at the umbo, sloping gently from there to the margins; usually the slope is convex, but in one example it is slightly concave; area narrow and vertical or slightly inclined over the hinge line; casts of the interior show the crura, points of attachment of posterior adductor scars, and area of attachment of diductor scars. Vascular and ovarian markings unknown.

Observations.—This shell has a wide geographic distribution. I have collected it at the type locality in the township of Georgia, Vermont; at Bic on the lower St. Lawrence River, and near the city of York at Emigsville, in central Pennsylvania. The matrix at Bic is a finely granular, slightly arenaceous limestone, in which the outer form of the shell is well preserved, but the spines are rarely seen; at Swanton and Georgia, Vermont, the shell occurs in siliceous limestone and arenaceous shale, and a cast of the outer surface shows the spines; the material from the finely arenaceous limestone at the Emigsville localities, discovered by Mr. E. Wanner, of York, is the best preserved, and affords excellent casts of the interior and exterior of the valves. In all of the localities the variation in the form and elevation of the ventral valve occurs, specimens of the ventral valve from Bic show a shorter deltidium than is usually present.

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[a] Through the courtesy of Dr. J. F. Whiteaves, of the Geological Survey of Canada, I had the opportunity of examining the types of *Orthisina festinata*. None of them preserve the apex of the deltidium, so it is impossible to determine upon what Mr. Billings based his statement that the deltidium is perforate.

A number of exfoliated shells occur in the collection from the dark gray compact limestone of eastern New York that are somewhat doubtfully referred to this species.

Nisusia festinata is a strongly marked species that appears to have but one near representative in *N.* (*Jamesella*) *perpasta.* The latter differs in the absence of spines and form of the ventral valve.

Formation and locality.—Lower Cambrian. Upper portion of Olenellus zone, Georgia formation. In limestone "lentile" about 2 miles east of Swanton; in silico-argillaceous shales, with *Olenellus thompsoni*, Parker's quarry, town of Georgia; and in arenaceous magnesian limestone about 2 miles east of Highgate Springs, Franklin County, Vermont. Also in dark gray limestone interbedded in siliceous shales 2 miles south of Middle Granville, Washington County, New York.

In limestone bowlder of the conglomerate on the east side of the entrance to Bic Harbor, Province of Quebec. Fragments of *Olenellus* and *Microdiscus* occurred in association with *N. festinata* in the limestone bowlders.

Emigsville limestone, on left bank of Codorus Creek, below Meyers Mill, near Emigsville, 4 miles from York, Pennsylvania.

NISUSIA FESTINATA TRANSVERSA Walcott.

Orthisina ? transversa WALCOTT, Bull. U. S. Geol. Sur. No. 30, 1886, p. 121, pl. VII, figs. 5, 5a.

Original description.—Shell small, transversely subquadrangular in outline, front broadly rounded, angle formed by the union of the cardinal slopes of the ventral valve 155° to 165°, hinge line straight and as long as the width of the shell. Area of the ventral valve of moderate height, bent back from the hinge line, divided by a triangular foramen that is higher than wide, and covered by a convex deltidium; the area of the dorsal valve is bent back at more than a right angle to the hinge line; foramen higher than wide, covered by a deltidium.

Surface marked by numerous radiating, fine, even costæ, eight in a distance of 3 mm., on the frontal margin of the ventral valve; a few concentric lines of growth cross the radiating costae, but not so as to give them a nodose character.

Interior characters unknown. The fine radiating striæ and transverse form distinguish this from other described species known to me.

Since 1886 I have obtained a much larger series of specimens, and do not think that this form should be considered more than a variety of *N. festinata.*

Formation and locality.—Lower Cambrian, Georgia formation. Silico-argillaceous shales of Parker's quarry, town of Georgia, Franklin County, Vermont.

JAMESELLA, new subgenus of **NISUSIA**.

There are several species of Lower Cambrian brachiopods that differ from *Nisusia festinata* in the absence of the strong spines on the radiating ribs. This character is so marked that I separate the species without it as a subgeneric group. The subgeneric name is in memory of Dr. Joseph F. James.

Type of subgenus, *Orthis perpasta* Pompeckj.

NISUSIA (JAMESELLA) AMII, new species.

Ventral valve convex, elevated at the umbo, with the beak slightly incurved; area high, vertical, slightly incurved; delthyrium triangular, higher than its greatest width and covered by a convex deltidium, which is imperforate. Surface of shell marked by numerous fine, rounded, equidistant ribs that increase by interpolation; about 8 ribs in a distance of 2 mm. at frontal margin. Size: Length, 8 mm.; width, 10 mm.; elevation at umbo, 4 mm.

The front margin of the deltidium broken so that it is impossible to state whether it was arched as is the deltidium of *Nisusia festinata*. There is no trace of a foramial aperture in the deltidium. The fine, regular ribs and high area serve to distinguish this from other species of the genus. Dorsal valve unknown.

The specific name is that of Dr. H. M. Ami, of the Canadian Geological Survey.

Formation and locality.—Lower Cambrian. I found this shell in a limestone bowlder of the Sillery conglomerate in association with fragments of Olenellus, 4 miles below Quebec, on south shore of St. Lawrence River, Canada.

NISUSIA (JAMESELLA) ARGENTA, new species.

Only the ventral valve is known of this species. Its outline is subrectangular with hinge line a little shorter than the greatest width. Strongly convex with a keel-like median elevation extending from the incurved beak over the elevated umbo to the front margin, with gradually increasing width. Surface marked by fine, concentric striæ of growth and about five sharp, elevated radiating ribs on each side of the two ribs on the median ridge. Area low, with the minute beak curving down to and possibly slightly over it.

This shell is represented by two specimens that have such strong characters that I unhesitatingly give them a specific name. The only form known to me that resembles them is *N.* (*J.*) *kuthani* of Bohemia.

Formation and locality.—Lower Cambrian. In shaly limestone containing fragments of *Olenellus*. Three miles southeast of Barrel Spring, one-half mile east of road, Silver Peak District, Nevada.

NISUSIA (JAMESELLA) ERECTA, new species.

General form transversely semioval; hinge line a little shorter than the greatest width; valves subequally convex. Surface marked by strong, broad, sharply rounded ribs, three at the frontal margin in a distance of 2 mm.; the ribs appear to be simple and unbifurcated from the umbo to the margin, but owing to the small size of the shell this statement may be modified by discovery of other specimens.

Ventral valve convex; elevated at the umbo, apex worn by attrition, but marginal. Area high, very slightly inclined backward; delthyrium large, triangular, length and width equal; deltidium convex, imperforate, and nearly covering the delthyrium. Dorsal valve regularly convex, most elevated at the umbo and curving over to the rather low area.

This species is distinguished by its strong, regular ribs and the regular convexity of the dorsal valve.

Formation and locality.—Middle Cambrian. Limestone at the south end of Timpapute Range, Groome District, Nevada.

NISUSIA (JAMESELLA) KUTHANI Pompeckj.

Orthis kuthani Pompeckj, Jahrbuch k. k. Geol. Reichsanstalt, XLV, 1896, p. 514, pl. xv, figs. 8–13.

(*Orthis romingeri* Krejci, Novak, K. Feistmantel, Kusta, Katzer, Wentzel, Jahn.)

Original description.—Outline subrectangular, hinge edge straight with angles protracted but a short distance; length to breadth as 3 : 4, often less.

Ventral valve highly arched. Apex drawn forward, but not curved toward the dorsal valve at all, or in rare cases but slightly. Area high, steep, with sharp areal edges and high, triangular foramen. Owing to the state of preservation, the details of the inside of the valves can not be well observed.

Dorsal valve flatter, with rather decided arching on side edge and frontal edge, with sinus always distinct, which corresponds to a faint swelling at the frontal edge of the ventral valve. The area is very low with a small triangular foramen. Crural processes narrow, considerably divergent.

The surface is ornamented with narrow sharp ribs, increasing by interpolation. The ribs are divided by interspaces which are considerably broader than the ribs. In the interspaces there is frequently seen a lower, thread-like rib. The number of ribs is 30 to 36. The ribs are mostly very distinct on the internal casts also. Sometimes internal casts are found which show remarkably few ribs, and which in this respect and also by their greater breadth approach *Orthis perpasta var. macra.*

The present species has thus far been called, after Kusta's example, *Orthis romingeri*, but it differs from that species (*a*) in the ventral valve, its apex never being so strongly curved as in *Orthis romingeri*, and in most cases not curved at all; (*b*) in the dorsal valve, which in the present species is more strongly arched with a more decided sinus; (*c*) in the sculpture, inasmuch as the ribs are narrower, sharper, fewer in number, and separated by wider interspaces than in *Orthis romingeri* Barr.

This species, eminently characteristic of the lower conglomerate zone of the Kamenná hůrka near Tejřovic, was found in thousands of specimens (impressions and internal casts) at the locality mentioned, in conglomerate-like, quartzitic sandstone and in the greywacke intercalations. I saw the species in similar rock from Gross Lohovic southwest of Skrej. (Collection of the Bohemian University at Prague.)

Observations.—In the material of this species Doctor Pompeckj sent me, there is one cast of a ventral valve that shows that a convex deltidium covered about two-thirds of the delthyrium; its front margin was arched so as to leave considerable space open between it and the place of the hinge line.

There is a decided mesial sinus in most specimens of the dorsal valve, but in some it is flattened so as to scarcely break the uniform low convexity of the valve; the strength of the mesial elevation of the ventral valve also varies from a marked ridge to a flattened median space.

The species appears to be quite distinct from any described Cambrian form.

Formation and localities.—Lower Cambrian sandstone of lower conglomerate zone. Localities in Bohemia as mentioned above.

NISUSIA (JAMESELLA) PERPASTA Pompeckj.

Orthis perpasta Pompeckj, Jahrbuch k. k. geol. Reichsanstalt, XLV, 1896, p. 515, pl. xv, figs. 15–18.

Original description.—Outline subrectangular, with straight hinge line and slightly bent frontal margin; cardinal angles slightly drawn in; the length is little more than half the breadth, the greatest breadth being in the middle of the valves. Both valves are very strongly arched.

The ventral valve has a high, steep area, with a large, triangular foramen, and the areal edges are rather sharp. The apex is not drawn forward beyond the hinge line. From the apex to the frontal edge there is a sinus which gradually increases to a considerable breadth. The dorsal valve, which is also strongly arched, has a very low and indistinct area, with a low, broadly triangular foramen. On the frontal margin a strong, broad swelling of the edge of the valve corresponds to the sinus of the ventral valve.

Judging by some internal casts and impressions, the shell is ornamented with some 40 broad ribs, of which about half are inserted between the primary ribs at various distances from the apex. Concentric lines of growth cross the ribs. On the top of the shells, along some of those lines of growth (1 or 2) the sections of the shell are found to be imbricated; near the frontal edge such imbrication is present more frequently in very short intervals.

Orthis perpasta differs from *Orthis Kuthani* by its greater breadth, by the almost uniform and much stronger arching of both valves, and also by the fact that in the former species the ventral valve bears a sinus, while in *Orthis Kuthani* the sinus is on the dorsal valve.

About 30 internal casts and impressions of dorsal and ventral valves were found in the conglomerate-like, quartzitic sandstone, and more rarely in the greywacke sandstone of the lower conglomerate zone on the "Kamenná hůrka" near Tejřovic.

Observations.—Doctor Pompeckj very kindly sent me several fragments of sandstone containing casts of the interior and exterior of the valves. The specimens illustrated by Doctor Pompeckj are smoother than most of those sent to me, but the description corresponds to the ribbed specimens, and a few nearly smooth interior casts occur in association with the more strongly ribbed shells. The convexity of the ventral valve is quite variable but is usually considerable. One of the marked characters of the dorsal valve is the large transverse space—pseudocruralium—beneath the umbo. In one example it is crossed vertically by the main vascular sinuses. What may be a trace of a low, simple, rounded cardinal process is shown in one cast. The crura were strong, with small dental sockets beside them.

N. (*J.*) *perpasta* resembles *Nisusia alberta* in form and convexity, but it does not have a spinose surface.

Formation and locality.—Lower Cambrian. Quartzitic sandstone of the "Skrej-band." Kamenná hůrka near Tejřovic; also Skrej (Slapnicky) Bohemia.

NISUSIA (JAMESELLA) PERPASTA MACRA Pompeckj.

Orthis perpasta macra Pompeckj, Jahrbuch k. k. geol. Reichsanstalt, XLV, 1896, p. 516, pl. xv, fig. 14.

Original description.—Some internal casts and impressions of dorsal valves agree in outline perfectly with the dorsal valves of *Orthis perpasta*, but differ from the type form by much less arching and ribs farther apart.

Occurs in the same localities as *Orthis perpasta.*

Observations.—The gradual increase in the width of the interspaces between the ribs, from a very narrow space to several times the width of the rib, makes this variety of doubtful value.

NISUSIA (JAMESELLA) PERPASTA SUBQUADRATA Pompeckj.

Orthis perpasta var. subquadrata Pompeckj, Jahrbuch k. k. geol. Reichsanstalt, XLV, 1896, p. 516, pl. xv, figs. 19, 20.

Original description.—As compared with the type form, this variety is distinguished by less breadth, the length being to the breadth as 3 to 4. The anterior angles of the straight hinge edge are drawn in somewhat more than in *Orthis perpasta* f. typ. The ventral valve is higher, with higher and steep area, pierced by a large triangular foramen. The sinus, which extends from the high vertical apex to the frontal edge, is bordered by obtusely rounded edges. Dorsal valve proportionally more bulged than in the type form. Sculpture as in *Orthis perpasta* f. typ.

The outer form strikingly recalls Orthisinae; but the pseudodeltidium, the median septum, and the spondylium of the ventral valve are lacking.

Orthis perpasta var. subquadrata was found in several internal casts and impressions, together with *Orthis perpasta* f. typ., more rarely in greywacke sandstone than in the conglomerate-like, quartzitic sandstone.

Observations.—This variety apparently is not constant, as ventral valves occur in the material before me that have the subquadrate form with relatively less convexity than the convex forms of the species *perpasta.*

NISUSIA (JAMESELLA) UTAHENSIS, new species.

Ventral valve transverse, strongly convex; most elevated at the umbo, which is surmounted by the upward pointing apex at the edge of the area; area slightly inclined forward from the hinge line; delthyrium large and covered by a convex deltidium. Surface marked by several strong, rounded ribs irregularly alternating with smaller ribs; fine, radiating striæ occur on the ribs and interspaces.

Only two specimens of somewhat imperfect ventral valves are known of this species. The description is of the best preserved specimen. The second specimen has a greater number of more regular ribs that increase by interpolation of short ribs. One specimen has a width of 8 mm. and a length of 4.5 mm. from the apex to the front margin, which is about the distance from hinge line to front margin.

The nearest related species is *Nisusia alberta*, from which it differs in surface ribs, forward inclination of the area, and prominent convex deltidium.

Formation and locality.—Middle Cambrian. Limestone about 50 feet above top of upper greenish shales, Rock Canyon, back of Provo, Utah.

NISUSIA (JAMESELLA), species undetermined

This doubtful species is based on an interior cast of a broken ventral valve. The width of the shell is 15 mm., and length 8 mm., with apex broken off. A broad, shallow sinus arches the frontal margin, and narrows toward the umbo. Radiating ribs narrow, about 5 in a space of 2 mm.

Formation and locality.—Lower Cambrian. Pinkish-colored limestone of Olenellus zone, coast of Labrador on Straits of Belle Isle.

EOSTROPHOMENA, new subgenus of STROPHOMENA.

The description of the type species gives all that is known of the subgenus. It differs from Strophomena in having the cardinal process in the dorsal valve merged into a ridge formed by the extension of the crural plates along the posterior margin, so as to cover the delthyrium and unite at the median line.

Type.—*Strophomena* (*Eostrophomena*) *elegantula*, new species.

Observations.—The cardinal process is more like that of *Orthothetes* than that of *Strophomena;* it differs from both in being more simple in its construction. It is probable that there is a group of shells having the characters of *S.* (*E.*) *elegantula*, but owing to the difficulty of obtaining interiors of the valves, it is impossible to designate them. *Strophomena aurora* Billings[a] is one of these; also *Leptæna decipiens.*[b]

STROPHOMENA (EOSTROPHOMENA) ELEGANTULA, new species.

General form transversely subsemicircular or subelliptical, greatest width at the straight hinge line. Surface concavo-convex, and marked by fine, radiating, even striæ, separated into flat bands by stronger and more prominent striæ or ribs; fine concentric striæ, and more or less prominent lines of growth cross the radiating striæ. The ventral valve is slightly convex, with low umbo and small, incurved apex. The dorsal valve is flattened in the umbonal region and concave toward the margins; the interior shows a narrow, rounded median furrow, also rounded crural plates that unite with the cardinal process to form a continuous ridge covering the anterior portion of the delthyrium; the dental sockets appear to have been relatively large and deep; the adductor muscle scars are a little to the front.

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[a] Pal. Foss., I, p. 218.

[b] Idem., p. 74.

A ventral valve 6 mm. wide has a length of 4 mm., and a dorsal valve 5.5 mm. wide is 3 mm. in length.

Observations.—The concavo-convex valves and the ridge representing the cardinal process place this little shell with the Strophomenoid forms, but as no described genus possesses the characters shown, a subgenus of *Strophomena* is made to receive it.

Formation and locality.—Upper Cambrian. Ceratopyge limestone associated with *Plectorthis daunus*, Oland, Borgholm, Sweden.

ORTHIS Dalman

Subgenus PLECTORTHIS Hall and Clarke.

Plectorthis HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, p. 194.

In their subdivision of the genus *Orthis* Dalman, Messrs. Hall and Clarke restricted the genus *Orthis* to the group of which *Orthis callactis* Dalman is the type, and, among American forms, *Orthis tricenaria* of the Trenton and Hudson faunas. These forms show the existence of a transverse apical plate in the delthyrium of the pedicle valve. A second group was placed under the name of *Plectorthis* and called the group of *Orthis plicatella*, and of this the authors say:

> This is a persistent form, which in American faunas, so far as known, is limited to the Trenton and Hudson River formations. While it retains the strong external ribs of the typical Orthis, these are not invariably simple (*O. fissicosta*, Hall; *O. triplicatella*, Meek; *O. æquivalvis*, Hall, not Davidson; *O. Jamesi*, Hall); the cardinal area of the pedical-valve is comparatively low and the valves are subequally convex. In the interior the character of the muscular scars, dental lamellæ and cardinal process is essentially the same as in Group I (Orthis), and the minute structure of the shell appears to be in precise agreement with that of *O. calligramma*, though no evidence of tubulose costae has been observed. In *Orithis Jamesi*, which is placed in this association, there is occasionally a deviation toward the resupinate contour exemplified in the Groups IV (*Orthis subquadrata*) and V (*Orthis sinuata*).

In the Cambrian faunas I find a group of species intermediate between the typical forms of *Billingsella* and of *Orthis*, as limited by Hall and Clarke, which appear to belong to the subgenus *Plectorthis*. This Cambrian group of shells may be defined as follows, the type of the subgenus being *Orthis plicatella* Hall, and its Cambrian representative, *Orthis remnicha* Winchell:

Diagnosis.—Shells subquadrate to transversely elongate; with or without median fold and sinus; valves subequally convex. Hinge line straight, usually forming nearly the greatest diameter of the shell. Cardinal extremities broadly angular, rarely acuminate. Surface with radiating ribs and striæ which may be crossed by concentric growth lines and striæ. The ribs increase as the shell grows, by interpolation.

The ventral valve has the umbo more or less elevated over the hinge line, the apex acute and usually incurved. The area is rather broad, flat or incurved and transversely striated. Teeth short and supported by dental plates that extend to the bottom of the valve, bounding a space (pseudospondylium) including the main vascular sinuses and area of attachment of the adductor muscle scars. Delthyrium open or partially closed by a convex deltidium. The adductor muscle scars are included within a narrow median area beneath the umbo on each side of the median line, and the diductors in a more or less flabelliform area outside of the main vascular sinuses. Pedicle scars unknown.

Dorsal valve with low umbo and slightly incurved apex; area well developed with a broad delthyrium. Deltidial cavity with a straight, simple cardinal process. Dental sockets small with short crura. The adductor muscle scars are small, the anterior being nearer the median ridge, which usually extends forward from the base of the cardinal process. Shell structure impunctate, and fibrous as far as known.

Type of subgenus.—*Orthis plicatella* Hall.

Observations.—The Cambrian species referred to *Plectorthis* have relatively thin shells that retain on the interior surfaces but slight traces of the muscle scars and vascular markings, except in the umbonal cavity.

The geological range of this subgenus in the Cambrian rocks is from the upper portion of the Middle Cambrian through the Upper Cambrian, and into the Ordovician, where it terminates in the Hudson River formation.

Two of the species from strata referred to the Middle Cambrian are represented by material too imperfect for specific description; they occur with *Paradoxides* in Bohemia, and it is not improbable that they will be found to belong to some other genus. *P. retroflexa* Matthew occurs in strata referred tentatively by Matthew to his Division E2 of the Cape Breton Cambrian section. He first referred the strata to the Ordovician. Of the remaining six species referred to Middle Cambrian strata *P. wichitaensis* occurs in the upper portion of the Middle Cambrian and base of the Upper Cambrian, and *P. indianola* also occurs in both Middle and Upper Cambrian.

From the above statements it will be seen that the first representatives of *Plectorthis* in the Cambrian appear in the Middle Cambrian, and that the greater number of species, 14 out of 21, are Upper Cambrian forms.

The species referred to the subgenus are as follows:

Name.	Cambrian.		
	L.	M.	U.
1. ? *atava* Matthew			x
2. *christianiæ* Kjerulf			x
3. *daunus*, new species			x
4. *desmopleura* Meek			x
desmopleura nympha, new variety			x
5. *diablo*, new species			x
6. *doris*, new species		x	
7. *hastingsensis*, new species		x	
8. *iddingsi*, new species			x
9. *indianola*, new species		x	x
10. *johannensis* Matthew			x
11. *kayseri*, new species			x
12. *linnarssoni*, new species		x	
13. *newtonensis* Weller			x
14. *pagoda*, new species			x
15. *papias*, new species		x	
16. *remnicha* Winchell			x
remnicha sulcata, new variety			x
remnicha texana, new variety			x
remnicha winfieldensis, new variety			x
17. *retroflexa* Matthew		x	
18. *saltensis* Kayser			x
19. *tullbergi*, new species			x
20. *wichitaensis*, new species		x	x
wichitaensis laeviusculus, new variety		x	x
21. *wimani*, new species			x
22. 2 species undetermined			

PLECTORTHIS ? ATAVA Matthew.

Strophomena atava MATTHEW, Trans. Roy. Soc. Canada, X, 1893, p. 102, pl. VII, fig. 8a–f.

Rafinesquina ? atava SCHUCHERT, Bull. U. S. Geol. Sur. No. 87, 1897, p. 338.

Description by Doctor Matthew.—Narrowly semicircular. Valves slightly arched, rather wider than the hinge line, compressed at the cardinal angles; sides of the valves nearly straight behind, regularly rounded in front.

Ventral valve moderately convex, highest and somewhat angulated at the middle of its length; umbo inconspicuous and appressed to the very narrow area.

Dorsal valve somewhat concave, especially toward the umbo, which is depressed to the general level of the valve.

The interior of the ventral valve has characters intermediate between those of Orthis and Strophomena. The ridges inclosing the cardinal muscles are shorter and closer at their extremities than in Strophomena, and the scar of the adductor muscle is broader and shorter, but extends half way to the front of the valve. There is a low sharp ridge at the umbo, between the branches of the posterior cardinal muscle, and the ventral cavity is faintly outlined in front. Another cast of the ventral valve of a larger individual, perhaps of this species, shows the impressions of the muscles more distinctly; in this the impression of the adductor muscle is much nearer to the hinge, being about two-thirds from the front of the valve; there is a low callus in front of the imprint of the adductor muscle.

A partly decorticated example of the dorsal valve exhibits a small bifid scar at the hinge line, due to the adductor muscle. There is no median ridge, such as is found in Orthis, the median sinus being almost obsolete. In front of the impression of the adductor muscle is a small, low callus.

Sculpture.—This consists of sharply raised, rounded, radiating ridges, slightly crenulated by obscure, transverse lines. These ribs are of varying size, every third or fifth rib being larger than the others; these large ribs extend outward from the umbo, and the smaller ones are intercalated between them, or spring from them. On the dorsal valve there are two main ribs in the sinus of the valve and three others extending to the lateral margins; smaller ribs are intercalated between these. On each side of the group of ribs on the middle third of the shell are four fainter, but more strongly arched groups of ridges, which throw off minor ridges at the back, directed toward the lateral margins. On the ventral valve the small ribs are almost all intercalated and do not spring from the back of the primary ribs, as in those of the dorsal valve.

Size: Length, 12 mm.; width, 14 mm.; height of area of dorsal valve, ½ mm., of ventral valve, 1 mm. A valve supposed to be of this species is 15 mm. long and 19 mm. wide.

Horizon and locality.—In dark shales of division 3a, at Navy Island.

Observations.—With the available data this species appears to be quite as near to *Plectorthis* as to any described genus. It does not appear to belong with the typical forms of *Strophomena* or *Rafinesquina.* The surface ribs, increasing by interpolation, and possibly bifurcation, and form of the pseudospondylium in the ventral valve, strongly suggest relationship with *Plectorthis.* It will probably require better preserved material to satisfactorily determine the correct generic reference for the species.

Formation and locality. Upper Cambrian. Division 3a of Matthew section. St. John terrane, Navy Island, St. John Harbor, New Brunswick.

PLECTORTHIS CHRISTIANIÆ Kjerulf.

Orthis christianiæ KJERULF, Veiviser ved. geol. Exk, i Christiania, 1865, pp. 1, 3, figs. 8a, b, c.

Orthis christianiæ BROGGER, Die Sil. Etagen 2 und 3, 1882, p. 48, pl. x, figs. 14a, b, c.

Orthis christianiæ GAGEL, Physik. Oekon, Gesellschaft-Konigsberg. Brach. Camb. und Sil. Diluvium Ost und Westpreussen, 1890, p. 34, pl. II, figs. 22a, 22b.

Orthis christianiæ POMPECKJ, Neues Jahrbuch, Min. Geol. und Pal., 1, 1902, Tremadoc der Mont. Noire, p. 7.

This shell appears to differ from any described species by the peculiarity of the bifurcation of the radiating ribs. In all the species I have referred to *Plectorthis* the increase in the number of ribs is by interpolation and not by true bifurcation. In *O. christianiæ* the increase is by both methods. The reference to *Plectorthis* is somewhat doubtful, as there is not sufficient data to base a reference on the characters of the interior, cardinal areas, or convexity of the valves.

I have received a large number of specimens from Norway and Sweden labeled *Orthis christianiæ.* After a study of all available material only the shells from the argillaceous shale of Russelökken, Norway, and Oland, Borgholm, Sweden, appear to belong to the species. The shells in the Ceratopyge limestone (*O. daunus*) have ribs that increase in number by interpolation of ribs in the interspaces between the older ribs, and a second species (*P. wimani*) that occurs in both the shale and limestone has simple ribs with few interpolated beyond the umbo. Another transverse form has simple strong ribs that increase in number by interpolation of a few new ribs.

Doctor Brogger's illustration of this species suggests *O. daunus* more than the typical form of *O. christianiæ*, as I understand and interpret it. "*Orthis parva*" Dalman, has sometimes been referred to *O. christianiæ.*

Dr. Curt Gagel described the form usually found in the limestone, stating that the surface is covered with strong dichotomous ribs. He found it in drift blocks of the Ceratopyge limestone near Belschwitz, also in glauconitic limestone near Preussinch, Holland, and Weblau.[a]

Dr. Ferdinand Roemer calls attention in his description of the drift in the North German plain to the fact that Remelé was the first to identify with certainty blocks of the Ceratopyge limestone of Sweden in the drift, the presence of a form like *Orthis christianiæ* being part of the evidence.[b] This shell was probably *Plectorthis daunus.* Doctor Roemer states in his description of the Ceratopyge limestone that a small Orthis (*? Orthis christianiæ*) predominates.

Formation and locality.—Upper Cambrian. Ceratopyge shale, Russelökken, Christiania, Norway. Borgholm, Oland, Sweden.

PLECTORTHIS DAUNUS, new species.

This species differs from *O. christianiæ* by having simple ribs that increase in number toward the front and lateral margins of the shell by interpolation of new ribs; no true bifurcation of the ribs was observed. A strong median sinus occurs on specimens of the dorsal valve in both shale and limestone. The shell is fibrous and impunctate. No traces have been seen of the fine, rounded, radiating striæ that occur on the broader ribs and interspaces of *P. christianiæ.* This species differs from *P. wimani* by its more transverse form and less simple ribbing of the shell.

Formation and locality.—Upper Cambrian. Ceratopyge limestone, Tören, Christiania; Slemenestad west of Christiania, Norway. Oland, Borgholm, Sweden.

PLECTORTHIS DESMOPLEURA Meek.

Orthis coloradoensis MEEK (not Shumard), Proc. Amer. Phil. Soc., II, 1870, p. 425.

Orthis desmopleura MEEK, U. S. Geol. Sur. Wyoming, Hayden, 1872, p. 295.

This shell has the general form and external characters of *O. wichitaensis.* It differs in being less convex and in the details of the radiating ribs. *O. desmopleura* differs from *O. remnicha* in its uniformly smaller size, less convexity, and in the details of the radiating ribs. The ribs have a wide range of variation, but when from the same character of matrix they are all of the same type, and the shells grade from one to the other.

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[a] Brach. Camb. und Sil. Geschiebe in Diluvium Prov. Ost und Westpreussen, p. 34.

[b] *Lethea Erratica* in Pal. Abbordl., II, Pt. 5, 1885, p. 36.

Nothing is known of the interior of the valves beyond an imperfect cast of the area of a dorsal valve. *Orthis hamburghensis* Walcott[a] is a closely related species and it may be identical.

Formation and locality. Upper Cambrian to Lower Ordovician. The Upper Cambrian locality is on Wolf Creek, 15 miles west-southwest of Sheridan, Wyoming, on the eastern slope of the Big Horn Mountains.

The type specimens are from near the base of the Ordovician rocks at Glen Eyre, canyon of Camp Creek, near Colorado City. The species has also been found on west side of Front Creek, below Beyer Park, Colorado.

PLECTORTHIS DESMOPLEURA NYMPHA, new variety.

This variety is based on strongly convex ventral valves in which the surface is marked by fine, radiating striæ, separated into bands of 3 to 6 striæ by stronger and more elevated striæ; concentric lines and often ridges of growth occur that on some shells give an imbricated appearance to the shell beyond the umbo.

Formation and locality.—In passage beds between the Upper Cambrian and Ordovician, on north side of Tepee Creek, Big Horn Mountains, Wyoming.

PLECTORTHIS DIABLO, new species.

This species is founded on a small, transverse shell that is marked by a few prominent radiating costæ that extend from the umbo to the margin of the shell. In the cast the costæ have a sharp summit and slope evenly to a narrow space between them.

A ventral valve 9 mm. in height has a width of 14 mm., which is about the average proportion of the specimens in the collection. The casts of the ventral valve show a rather low area divided by a delthyrium, the inner angles of which have a rather strong tooth on each side. The dental plates extend backward farther than in most species of the genus, becoming attached to the bottom of the valve only near the teeth, and not extending forward as in *P. remnicha* to form a pseudospondylium. None of the specimens in the half dozen shells in the collection show the muscular or vascular markings. There may or may not be a mesial depression on either valve.

Formation and locality.—Upper Cambrian. St. Croix sandstone of Trempealeau, Wisconsin.

PLECTORTHIS DORIS, new species.

Of this species a ventral and dorsal valve occur in the collection. The general form is rounded subquadrangular. The ventral valve is strongly convex with the greatest height at the umbo, from which the beak arches over a high, backward inclining area. The dorsal valve is much like the ventral in form, except that it is less convex and less elevated at the area. Surface of both valves with numerous radiating ribs that have an angular summit and an angular depression between them. The ribs increase in number toward the front by interpolation. The ventral valve has a length of 7 mm.; width 8 mm. The dorsal valve is a little shorter than the ventral.

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[a] Mong. VIII, U. S. Geol. Surv., 1884, p. 73, pl II, figs. 5, 5a.

This shell is not unlike *Plectorthis indianola* in form and surface characters. It differs in being more convex and in the absence of a sinus or median fold on either valve.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Two and three-quarters miles southwest of Yen Chuang, Shantung, China.

Collection of Mr. Eliot Blackwelder, Carnegie Institution Expedition to China.

PLECTORTHIS HASTINGSENSIS, new species.

Shell transversely subelliptical. Surface with numerous strong, rounded, radiating ribs increasing in number by interpolation. The ribs appear to be broader and with narrower interspaces on the ventral valve; concentric ridges and fine striæ of growth are a marked feature of the surface. A ventral valve 4 mm. in length has a width of 6 mm.; a dorsal valve 6 mm. long is 10 mm. in width.

Ventral valve strongly convex, most elevated on the umbo, and without mesial fold; apex incurved slightly over the delthyrium area well defined, and divided midway by a large delthyrium, it is inclined but little from the vertical.

Dorsal valve slightly convex in young shells, and becoming more so as they increase in size; area low and inclined backward over the hinge line.

Observations.—This species is unlike other described forms in the character of its ribs, with the exception of *Plectorthis johannensis*, which it resembles very closely. Doctor Matthew describes the latter species as having a very thin shell, and it is found in the Upper Cambrian at St. John. No interior features have been seen. Dr. G. F. Matthew mentions having found fragments of *Protorthis* or *Orthis* in the phosphate nodules at Hastings Cove, too imperfect for description.[a]

Formation and locality.—Middle Cambrian. Upper Paradoxides zone. Hastings Cove, Kennebecasis River, at base of Paradoxides zone, Hanford Brook, in limestone and superjacent shale, St. John County, New Brunswick.

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[a] Trans. Roy. Soc. Canada, 2d ser., III, 1897, p. 180.

PLECTORTHIS IDDINGSI, new species.

General form and convexity much like that of some varieties of *P. indianola.* Its surface characters also approach those of the more regularly ribbed shells of the latter species. The principal difference is in the less convexity, lower umbo, and lower area of *P. iddingsi.* The interior of the ventral valve shows a short, well-defined umbonal cavity, with a strong vascular sinus on each side of it that extends well forward into the valve.

The species is named after Prof. Joseph P. Iddings of the University of Chicago, formerly of the U. S. Geological Survey, who collected the specimen.

Formation and locality.—Upper Cambrian. Gallatin terrane, south side of Gallatin Valley, Yellowstone National Park, Wyoming.

PLECTORTHIS INDIANOLA, new species.

Shell small, transverse, with the cardinal extremities rounded, angular, and in some specimens almost alate. Valves moderately convex, the ventral nearly twice as much so as the dorsal; the hinge line varies in length from slightly less than the greatest width of the shell to where, in the shells with extended cardinal extremities, it is one-fifth greater than the width of the shell across the center.

The ventral valve may or may not have a mesial depression. In some examples the depression is broad and rounded, and in others it is shallow with stronger ribs at each margin; umbo somewhat elevated, and curving over toward the hinge line, beyond which it projects, terminating in a small, incurved beak; dorsal valve considerably less convex than the ventral; beak small and projecting slightly over the hinge line. The median sinus in the dorsal valve varies from a broad, shallow depression to a narrow, rather deep furrow that gives a bilobed appearance to the valve.

The surface is quite variable in the strength and arrangement of the strong and minor radiating elevated ribs and striæ. On some shells they are very fine and of nearly equal size, separated by grooves of about the same width as the ribs or striæ. In other examples every third or more widely separated rib is stronger and elevated above a more or less broad interspace marked by fine ribs or costæ.

Almost nothing is known of the interior of the valves. A few specimens show a well-marked umbonal cavity beneath the umbo that is much like that of *O. remnicha.* The area of the ventral valve is inclined backward at an angle of about 65° to the plane of the margin of the valve. It is rather low and broken midway by a strong delthyrium. The area of the dorsal valve is low and inclined well out over the hinge line.

Observations.—*Plectorthis indianola* is almost as variable in its form and surface markings as *P. wichitaensis*, with which it is associated at a number of localities. It differs from the latter in the bilobed dorsal valve, more strongly incurved umbo and apex of the ventral valve, and the general appearance of convexity and rotundity of the ventral valve. When the specimens of the two species are imperfect, or the young shells of *P. wichitaensis* occur in association with the shells of *P. indianola* it is difficult to determine positively to which species they belong.

Formation and locality.—Upper Cambrian. Top of Reagan formation, west side of Honey Creek, near SE. corner sec. 35, T. 1 S., R. 1 E., Ardmore quadrangle, northwest extremity of Arbuckle Mountains, about 4 miles east of Homer, Indian Territory. Reagan greensand, two-thirds of a mile east of Canyon Creek, 15 miles northwest of Fort Sill, SE. ¼ NE. ¼ sec. 2, T. 4 N., R. 13 W., Wichita Mountains, Oklahoma Territory.

Middle Cambrian. Reagan Formation, SW. ¼ sec. 17, T. 4 N., R. 12 W., Wichita Mountains, 11 miles northwest of Fort Sill, Oklahoma Territory. Potosi limestone, near Potosi, Missouri. Limestone on Cold Creek, north end of gorge, opposite north end of Sponge Mountain, Llano County, Texas.

PLECTORTHIS JOHANNENSIS Matthew.

Orthisina (?) *johannensis* MATTHEW, 1891, Trans. Roy. Soc. Can., IX, 1891, p. 49, pl. XXII, figs. 13a–e.

Original description.—Shell subquadrate, doubly convex, rather flat, very thin.

Dorsal valve depressed at the sides and front, and having a broad, shallow median sinus. The valve is about one-quarter wider than long, and the hinge line is nearly as long as the length of the shell. Umbo slightly elevated, hinge plate weak and thin.

Ventral valve depressed at the sides, and having a few median ridges running from the umbo to the front of the shell. This valve is somewhat geniculated at two-fifths of its length from the umbo, and from the bend faintly raised ridges diverge to the anterior angles of the shell; behind the geniculation the surface of the shell is marked by faint undulations similar to those of *Strophòmena rhomboidalis.*

The umbo is not prominent, but the back of the valve is regularly curved and the area rather low.

Sculpture.—Closely set striæ radiating from the umbo and faint concentric striæ mark the shell.

Size.—Length of the ventral valve, 9 mm.; width, 10 mm. Length of dorsal, 8 mm.; width, 10 mm.

Horizon and locality.—[Upper Cambrian C. D. W.] Limestone lentilles in the black shales of division 3a, Germaine street, St. John.

This species has a low umbo for an *Orthisina*, and in its form recalls the genus *Strophomena*, as also do the concentric undulations that are found on the back of the ventral valve. The dorsal valve, however, is convex, and the area of this and the ventral valve too high for a *Strophomena*. It does not appear to agree with any described species of *Orthisina*. It resembles *O. orientalis* White, somewhat in form, but is not so long nor so wide at the hinge. From *O. pepina* Hall, it differs in its lower umbo and area, shorter hinge, and smoother surface. It approaches more closely to the form from the Potsdam sandstone of the West, figured by Professor Hall, but not named, except as a *Strophomena* or *Strophodonta*."[a]

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[a] Preliminary Notice of the Fauna of the Potsdam Sandstone. Sixteenth Rep. N. Y. State Cab. Nat. Hist., pl. VI, fig. 22.

Doctor Matthew very kindly sent me the types of this species. There is little that can be added to his very complete description. As far as known, the characters of the shell are those of the group of species referred to, *Plectorthis*.

PLECTORTHIS KAYSERI, new species.

This is a larger shell than *Plectorthis linnarssoni*, with which it is associated. Its surface is marked by numerous fine radiating striæ, 4 to 5 in a distance of 1 mm., and the inner layers of the shell appear to be minutely punctate. The ventral valve is more convex than the dorsal, the latter being nearly flat in young shells. Nothing is known of the interior except one cast of the pseudospondylium of the dorsal valve, which is larger in proportion than that of *P. linnarssoni*.

The largest ventral valve has a length of 14 mm.; width, 20 mm.

This species belongs in the group of Plectorthis represented by *P. desmopleura* and *P. linnarssoni*.

The species is named after Dr. Emanuel Kayser.

Formation and locality.—Upper Cambrian. Lower part of Chao Mi Tien (?) limestone, 2.7 miles southwest of Yen Chuang, and Chao Mi Tien, Province of Shantung, China. Collected by Eliot Blackwelder and Bailey Willis of the Carnegie Institution Expedition, 1903.

PLECTORTHIS LINNARSSONI Kayser.

Orthis linnarssoni KAYSER, Cambrische Brach., von Liau-Tung, China, Richthofen, IV, 1883, p. 34, pl. III, fig. 1.

Original description.—Shell semielliptic in outline, broader than long, with hinge edge straight, corresponding to the greatest breadth of the shell. Large [ventral] valve moderately convex. Small [dorsal] valve slightly arched, with a sinus developing already at the umbo, and growing quite broad and deep toward the edge. Umbo of ventral valve small, area very low. Surface of shell covered with rather sharp ribs, very variable in strength, separated by narrow furrows. By reason of repeated splitting, beginning close to the umbo, the ribs appear rather as bundles of ribs. On the matrix these bundles appear as broad, obtuse-angled folds, which, owing to repeated marginal splitting in even a higher degree than on the shell itself, appear as bundles of ribs of very unlike strength. When the surface is well preserved, a delicate concentric growth striation is perceptible.

Doctor Kayser compares this shell with *Orthis hicksi* Salter, and *O. exporecta* Linnarsson, on account of the surface characters. It does not appear to be very closely related to either species, but it is in many respects allied to *Plectorthis desmopleura* and *P. wichitaensis*. *P. linnarssoni* differs from both in being more transverse.

Formation and locality.—Middle Cambrian. Lower part of Chao Mi Tien (?) limestone, 2.7 miles southwest of Yen Chuang, Province of Shantung, China. Collected by Eliot Blackwelder and Bailey Willis, of the Carnegie Institution Expedition, 1903.

PLECTORTHIS NEWTONENSIS Weller.

Orthis newtonensis WELLER, Geol. Sur. New Jersey, Pal., III, 1903, Pal. Faunas, p. 113, pl. I, figs. 3–5.

This little shell occurs in the form of casts in a sandstone that is too coarse to preserve the details of the outer surface. The cast of the interior shows fine, simple, radiating ribs that increase by interpolation and that are coarser on the ventral than on the dorsal valve. Ventral valve slightly flattened at the front; dorsal valve with a broad mesial sinus. The shell appears to have been thin. The cast of the pseudospondylium of the ventral valve shows it to have been clearly defined; the area is low and not sharply defined from the curve of the cardinal margin; it is nearly vertical to the plane of the margin of the valve. The cast of the area beneath the umbo in the dorsal valve is more triangular and less transverse than usually occurs; unfortunately the material is too imperfect to determine any details.

This species is the eastern representative in the Upper Cambrian of *Plectorthis indianola* and *iddingsi*. As far as can be determined by the material available for comparison, it is closely related to them, but it is not probable that they are specifically identical.

Formation and locality.—Upper Cambrian sandstone, Hardyston quartzite of Weller, Newton, New Jersey.

PLECTORTHIS PAGODA, new species.

Shell transverse, subsemicircular; a ventral valve 11 mm. in length has a width of 15 mm., and a dorsal valve 8 mm. in length has a width of 13 mm.; hinge line a little shorter than the greatest width of the shell; cardinal angles vary from 75° to 111°; valves moderately convex. Cardinal area narrow in both valves and inclined backward from the hinge line. Surface marked by equidistant, narrow, low ribs, 3 in a space of 2 mm. near the front margin of a shell 10 mm. long, with fine, radiating striæ between them; the radiating ribs and striæ are crossed by fine, concentric striæ, and lines of growth.

Ventral valve with a strong, somewhat angular, median fold, rising from a well defined depression on each side of it, or it might be designated as a very strong rib rising above the general surface of the valve from a broad, median depression; the lateral slopes are gently convex. Dorsal valve with a strong, angular, median depression, beginning at the posterior margin and gradually widening to the front; the sides of the depression rise above the general surface of the valve, and form with the outer slope a well defined, low ridge on each side that extends a little forward on the front margin to fit into the depressions on each side of the median fold of the ventral valve.

The interior of a small dorsal valve has a broad, strong median ridge corresponding to the depression on the exterior surface; a main vascular sinus starts on each side of the base of the median ridge and arches outward and then forward about a depressed oval space on each side of the ridge; lateral branches extend from the main sinus toward the sides; the impressions of the anterior and posterior adductor muscle scars occur on the slopes of the median ridge and the oval depressions; somewhat obscure radiating lines mark the anterior portion of the surface.

Observations.—This shell is distinguished by its strongly marked median ridge on the ventral valve and sinus on the dorsal valve. In general form and surface markings it is not unlike *Plectorthis desmopleura* and *Plectorthis wichitaensis*.

Formation and locality.—Upper Cambrian. Chao Mi Tien limestone, two-thirds miles west and Pagoda Hill, one mile west-southwest of Tai An Fu, Shantung, China.

Collection of Eliot Blackwelder, Carnegie Institution Expedition to China.

PLECTORTHIS PAPIAS, new species.

This species is founded to receive a form represented by two small dorsal valves from the Paradoxides zone of Newfoundland. They are moderately convex, with a low area divided by a broad delthyrium; surface marked by numerous, rounded, depressed ribs, crossed by concentric striæ and ridges of growth. Length of shell 4 mm.; width, 5 mm.

Formation and locality.—Middle Cambrian. Paradoxides zone. Shales with *Paradoxides davisi* and 40 feet lower in the section. Manuels river, Conception Bay, Newfoundland.

PLECTORTHIS REMNICHA Winchell.

Orthis remnicha N. H. WINCHELL, Fourteenth Ann. Rep. Geol. Nat. Hist. Survey Minnesota, 1886, p. 317, pl. II, fig. 7.

Orthis? remnicha WALCOTT, Mong. XXXII, U. S. Geol. Survey, 1899, pp. 451, 452, pl. LXI, figs. 3, 3a; pl. LXII, figs. 1, 1a-d.

Shell of medium size, usually slightly transverse, with an oblong, oval outline for the ventral valve, and a subquadrate to semicircular outline for the dorsal valve. Valves moderately convex, with an almost straight hinge line that varies in length from nearly the greatest width of the shell to two-thirds the greatest width; cardinal angles varying from 90° or less in the extreme forms, with extremities somewhat angular, to the other extreme, where they are very obtuse and have the appearance of being almost rounded, their angle being not less than 120°. Cardinal area narrow, but well developed on each valve, and divided by a rather large delthyrium.

The ventral valve has in some specimens a shallow mesial depression, and in some examples it is flattened toward the cardinal angles; beak small and curving down toward the hinge line, beyond which it projects slightly. Dorsal valve slightly less convex than the ventral; beak small, scarcely projecting beyond the hinge line.

Surface marked by bifurcating, radiating costæ, that vary on shells of similar size from 16 in the space of 5 mm. to 3 in the same space. This variation is shown in the specimens from Texas, Wisconsin, and Wyoming. In well preserved specimens very fine, radiating, raised striæ occur both on the costæ and on the intervening depressions. These are shown on the casts of the shells from the St. Croix sandstone of Winfield, Wisconsin, and on the larger shells from the limestones of Indian Territory and the Yellowstone National Park.

The interior of the ventral valve shows a slightly raised, rather small tripartite umbonal cavity beneath the umbo, which is the only trace of interior markings of this valve observed. The interior of the dorsal valve has a slightly elevated area upon which occurs a narrow, short median septum. The crural plates are also well shown. In casts of the interior from the St. Croix sandstone of Wisconsin the dental lamellæ of the ventral valve are finely shown, and in the dorsal valve the median septum and crural plates.

This is one of the most variable shells that occur in the Cambrian fauna. Its range of variation is such in all of the widely separated localites in which it occurs that one would scarcely hesitate, if in possession only of the extremes, to identify two well-marked species. The variation is not only in the radiating costæ, but also in the general form of the shell. This variation is expressed in three varieties that receive names, and others might be designated if more minute variations were given consideration.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Red Wing, Minnesota. Four miles north of Reedsburg and at Winfield, Wisconsin.

Near base of Upper Cambrian, on ridge eight miles east of Yellowstone River, three miles north-northeast of Mount Delano, Park County; Gallatin terrane, Crowfoot section, Gallatin Range, Yellowstone National Park. It also occurs at a slightly lower horizon on the south side of the Gallatin Valley, and specimens were collected farther to the north by Dr. A. C. Peale, opposite the mouth of Pass Creek, in the Gallatin Valley, Montana.

Upper division of Reagan formation, NW. ¼ sec. 1, T. 2 S., R. 1 E. West side of Honey Creek, near SE. corner sec. 35, T. 1 S., R. 1 E. Ardmore quadrangle; northwest extremity of Arbuckle Mountains, about 4 miles east of Homer, Indian Territory.

PLECTORTHIS REMNICHA SULCATA, new variety.

This variety is founded on the strongly sulcate dorsal valve. The ventral valve shows only a slight flattening of the median portion.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Winfield, Taylors Falls, and four miles north of Reedsburg, Wisconsin.

PLECTORTHIS REMNICHA TEXANA, new variety.

The rounded, subquadrate form, and the arrangement of the radiating costæ serves to differentiate this variety. This costæ vary considerably on different shells, but the tendency of the larger number is toward a surface characterized by narrow, evenly spaced, radiating ribs; fine radiating striæ occur on the ribs and interspaces. A shell that is doubtfully referred to this variety occurs in the silicious Middle Cambrian limestones, 50 feet above the conglomerate series, St. Francis County; also in section 22, township 35 of Iron County, Missouri.

Formation and locality.—Upper Cambrian. Cold Creek Canyon, Burnett County; on Cold Creek, north end of Sponge Mountain, 2 miles south of San Saba County line in Llano county, Texas. Arbuckle limestone, NE. ¼ sec. 2, T. 2. S., R. 1 E., Ardmore quadrangle, Indian Territory.

PLECTORTHIS REMNICHA WINFIELDENSIS, new variety.

This variety is characterized by having finer and more uniform costæ than any of the shells referred to *P. remnicha.* The costæ increase by interpolation rather than bifurcation in the true sense of the word. The shorter costæ begin as very narrow, sharp ridges, merging into the sides of the larger costæ below the summit of the latter, or they may arise entirely on the interspaces between the costæ. The pseudospondylium is less strongly developed than in *P. remnicha.* The young shells are usually narrower at the hinge line than the adult; but this feature is sometimes present in large shells.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Winfield, Pilot Knob, and doubtfully Trempealeau, Wisconsin.

PLECTORTHIS RETROFLEXA Matthew.

Gonambonites plana var. *retroflexa* de Verneuil, Beitrage zur Geognosie des Russischen Reiches, 1830, p. 77, pl. xxv, figs. 1, 2.

Clitambonites (*Gonambonites*) *plana* var. *retroflexa* Matthew, Trans. Roy. Soc. Canada, 2d ser., I, 1896, p. 266, pl. ii, figs. 1a–e.

Clitambonites planus retroflexus Schuchert, Bull. U. S. Geol. Survey No. 87, 1897, p. 184.

Billingsella retroflexa Matthew, Geol. Sur. Canada, Rep. Cambrian Rocks, Cape Breton, 1903, p. 148, pl. x, figs. 2a–e.

This species is distinguished by the fine radiating costæ on the ventral valve and coarser costæ on the dorsal. The fine, longitudinal striæ are similar to those of *P. remnicha.* In a specimen of the ventral valve, the pseudospondylium, area, and base of the main vascular sinuses are shown. Specimens of the dorsal valve show the cast of the strong cardinal process, dental sockets, and crura, and the ovarian areas and visceral area between. Doctor Matthew describes other features of the interior of the valves.

The character of the costæ and general features of this shell, as far as known, appear to class it with *P. remnicha* and allied forms.

Formation and locality.—Middle Cambrian. Sandstone and sandy shales, McFees Point, near George River station, Cape Breton, Nova Scotia.

PLECTORTHIS SALTENSIS Kayser.

Orthis saltensis KAYSER, Palæontographica, Primord, und Sil. Foss. Argentinischen. Rep., 1876, p. 8, pl. I, fig. 16.

Doctor Kayser's description of the figures lead me to refer this species to the genus *Plectorthis*. The general form of the valves, the casts of the interior of the ventral valve, with the strong umbonal cavity and the radiating ribs, increasing in number by intercalation of new ribs, appear to sustain the reference.

Formation and locality.—Upper Cambrian. Sandstone of Salta and Nevado de Castillo, and at Tilcuya, Argentine Republic.

Doctor Kayser also described and illustrated the dorsal valve of a shell that he referred to *Orthis* sp. It suggests *Orthis* (*Orusia*) *lenticularis*.

PLECTORTHIS TULLBERGI, new species.

This shell occurs in the passage beds to the Ordovician at the top of the Ceratopyge zone. Its transverse outline and simple, strong ribs serve to distinguish it from *P. christianiæ* and *P. daunus*.

The specific name is given in memory of Sven Axel Tullberg.

Formation and locality.—Upper Cambrian. Ceratopyge zone, Olands, Borgholm, Sweden.

PLECTORTHIS WICHITAENSIS, new species.

In general form and outline this shell is related to *P. desmopleura* and *P. remnicha*. It is more convex and differences in the radial ribbing and striation separate it from the former species, and it occurs in an older geological formation. Its convexity and surface characters distinguish it from *P. remnicha*.

A considerable number of relatively smooth shells occurs in the collections that may be designated as a variety, but it is often difficult to separate them from the more finely ribbed specimens that are typical of the species.

Formation and locality.—Upper part of Middle Cambrian and base of Upper Cambrian.

Middle Cambrian, Reagan formation. A little south of W. ½ of sec. 2, T. 4 N., R. 13 W. One-quarter mile south of Canyon Creek Camp, 15 miles northwest of Fort Sill, Wichita Mountains. Also in same area near middle of west half of sec. 13, T. 4 N., R. 13 W.; 2 miles south and 1 mile east of Canyon Creek Camp; also in SW. ¼ sec. 17, 4 miles east of Canyon Creek Camp, 11 miles northwest of Fort Sill, Oklahoma Territory. Cold Creek, north end of gorge opposite north end of Sponge Mountain, Llano County, Texas. Conglomerate series and 50 feet above, St. Francis County, Missouri. Upper Cambrian. Lower part of Arbuckle limestone. At small hill 2 miles southwest of Signal Mountain, Wichita Mountains, Oklahoma Territory. Reagan formation, top beds, west side of Honey Creek near SE. corner sec. 35, T. 1 S., R. 1 E.; NW. ¼ sec. 1, T. 2 S., R. 1 E., Ardmore quadrangle. Northwest extremity of Arbuckle Mountain, about 4 miles east of Homer, Indian Territory.

PLECTORTHIS WICHITAENSIS LAEVIUSCULUS, new variety.

A variety with small, narrow, numerous ribs is given the above name. Many graduations exist between it and the typical forms of *P. wichitaensis*.

Formation and locality.—Same as *P. wichitaensis* in Oklahoma and Indian Territories.

PLECTORTHIS WIMANI, new species.

This shell is distinguished from *P. christianiæ* and *P. daunus* by the rounded, narrow, simple ribs, less transverse and more rounded outline. A ventral valve shows a well-defined pseudospondylium with the tripartite division as seen in *Plectorthis remnicha*. Two strong main vascular sinuses extend forward from the lateral divisions of the umbonal cavity nearly to the front of the valve, corresponding in position to those of the dorsal valve. The cast of the dorsal valve indicates the presence of rather strong crura, crural plates, teeth sockets, and delthyrium.

The ventral valve is rather strongly convex and dorsal valve about one-half as much so. The average size is 6 mm. to 7 mm. in diameter, the ventral valve being about 1.5 mm. larger than the dorsal. The largest ventral valve in the material available for study has a length of 9 mm.

The species is named after Dr. Carl Wiman in recognition of his excellent work on the cambrian faunas of Sweden.

Formation and locality.—Upper Cambrian. Ceratopyge zone. Limestone at Oland, Borgholm, Sweden. Limestone at Slemenstad west of Christiania; black argilaceous shale, Christiania, Norway.

PLECTORTHIS 2 Sp.?

Dr. J. F. Pompeckj[a] mentions two species of *Orthis* from the Middle Cambrian green Paradoxides shales of Bohemia which appear, from the illustration, to belong to the genus *Plectorthis*. The material is too imperfect to base specific determinations upon. Doctor Pompeckj describes them as follows:

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[a] Jahrbuch k. k. geol. Reichsanstalt, XLV, p. 514, pl. xv, fig. 6 and fig. 7.

(Plate xv, fig. 6.)

Orthis sp.—In the green Paradoxides slate of the Dlouhá hora above the brook of Zbirov near Skrej there were found some impressions of dorsal valves, which depart from *Orthis romingeri.* The ribs are remarkably broad, flat, and separated by narrow interspaces; ribs may be observed to be split several times.

(Plate xv, fig. 7.)

Orthis sp.—The impression of a dorsal valve from green Paradoxides slate in the gorge above Luh near Skrej also departs from *Orthis romingeri* by its greater breadth and less distinct ribbing.

ORUSIA, new subgenus of ORTHIS.

Orthis lenticularis of authors is not an *Orthis* as restricted by Hall and Clarke.[a] It appears to belong more nearly to the group of species assembled under *Plectorthis.* It departs from *Plectorthis* in its very thin shell, subequally convex valves, small umbonal cavity, and wide variation in form and surface characters, and is here placed under a new subgenus.

The only species of the subgenus *Orusia* is *O.* (*O.*) *lenticularis* which occurs in the Upper Cambrian. Another species that is doubtfully referred to the subgenus is *O.* (*O.*?) *eurekensis* a Middle Cambrian form that appears to be nearer *O.* (*O.*) *lenticularis* than to other known species of the genus *Orthis.*

The species referred to *Orusia* are:

Name.	M.C.	U.C.
1. (*Orusia*) *lenticularis* Wahlenberg		x
(*Orusia*) *lenticularis atrypoides* Matthew		x
(*Orusia*) *lenticularis lyncioides* Matthew		x
2. (*Orusia?*) *eurekensis* Walcott	x	

ORTHIS (ORUSIA) LENTICULARIS Wahlenberg.

Anomites lenticularis WAHLENBERG, Nova Acta Upsala, VIII, 1821, Petr. tell. Suec., p. 66.

Atrypa? lenticularis DALMAN, Kongl. Utenskaps Acad. Hand., 1827, p. 132.

Spirifera lenticularis VON BUCH, Abhandl d. Berl. Akad., 1834, p. 48, pl. I, figs. 13, 14.

Atrypa? lenticularis HISINGER, Lethæa Svecica, 1837, p. 76.

Atrypa lenticularis KJERULF, Geol. d. südl. Norw., 1857, p. 284; Veiviser ved. geol. exc. i. Christiania omegn., 1865, p. 3, fig. 7; Syd. Norges geol. atlas, 1879, pl. XIII.

Orthis lenticularis SALTER, Mem. Geol. Sur. Great Britain, III, 1866, p. 339, pl. IV, figs. 8–10.

Orthis lenticularis DAVIDSON, Geol. Mag., V, 1868, pl. XVI, figs. 20–22; British Foss. Brach., III, 1871, p. 230, pl. XXXIII, figs. 22–28.

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[a] Pal. N. Y., VIII, Pt. 1, pp. 192–194.

Orthis lenticularis? KAYSER, Palaeontographica, Primordiale und untersil. Foss. Argentinischen Republik, II, 1876, p. 9, pl. I, figs. 11, 12.

Orthis lenticularis BROGGER 1882, Die Sil. Etagen, 2 und 3, p. 48.

Orthis lenticularis MATTHEW, Trans. Roy. Soc. Canada, IX, 1891, p. 46, pl. XII, figs. 9a–d.

Orthis lenticularis var. *strophomenoides* Matthew, Trans. Roy. Soc. Canada, IX, 1841, p. 49, pl. XII, figs. 12a, 12b.

Dr. George F. Matthew in his excellent review of the descriptions of this species gives a translation of Wahlenberg's original description, together with the Latin; also Dalman's, Leopold von Buch's, and Salter's descriptions.

He calls attention to the fact that if the reader will compare the several descriptions of this species by the authorities named he will be surprised at the diversity they exhibit. This diversity, Doctor Matthew thinks, is due partly to the imperfect descriptions of the earlier writers, but chiefly to the remarkable variability of the species.[a] Doctor Matthew recognized the species in the Upper Cambrian, St. John, New Brunswick, and he also distinguished three varieties. Through Doctor Matthew's kindness I had the opportunity of studying the types of the varieties.

Through M. Schmalensee, collector of the geological survey of Sweden, I secured a large and fine series of this species from thin bands of limestone in the Olenus and alum shales at Olands and Nunneburg. I also collected a quantity of the shells from the Upper Cambrian of Manuels River, Newfoundland. From this material an attempt has been made to select a series illustrating the great range of variation in form and surface markings; first, from Sweden; second, Newfoundland, and third, New Brunswick. I was not able to obtain satisfactory material from Wales, but Mr. Davidson's figures illustrate fully the peculiarities of the species as it occurs there. These illustrations will appear in the completed monograph on the Cambrian brachiopoda.

Only one specimen was found in which the two valves were united. The convexity of the two valves is subequal, the ventral being a trifle greater.

A very careful search has been made of casts of the interior to illustrate the muscle scars and vascular markings. In a few instances traces have been found. One of these shows the area (pseudospondylium) beneath the umbo of the ventral valve; also the main vascular sinuses. Doctor Matthew illustrates some traces of the vascular markings and muscle scars, but they are almost too indefinite to be of value.

In a single specimen of the ventral valve from Olands, the cast of the umbonal cavity is nearly as sharp as in some specimens of *Plectorthis remnicha*. The cavity is tripartite, the central division being occupied by the diductor muscle scars, and the two lateral divisions are continuous with the ridges representing the casts of the main vascular sinuses. I have been unable to determine positively whether there is a deltidium present or not. The delthyrium is clearly shown in several specimens. Casts of the interior of the dorsal valve from Newfoundland show the presence of crural plates that extend to the bottom of the valve; also short, but very definite, crura and small depressions beside the latter for the reception of the teeth of the ventral valve. A cast of the ventral valve shows that the ventral plates extend to the bottom of the valve, and specimens from Sweden show that the dental plates and a transverse arching ridge sharply define, in certain individual ventral valves, the umbonal cavity.

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[a] Trans. Roy. Soc. Can., IX, 1891, pp. 46–47.

The average size of the specimens from Olands is about 5 by 6 mm. One dorsal valve is 7 by 9 mm. Those from Nunneberg average from 5 to 6 mm., with occasional shells 7 by 8. In Newfoundland great numbers occur 4 by 5 mm., but there are also examples having a height of 10 mm., with a width of 12 mm. Doctor Matthew states that the medium size of the shell is about 5 by 6 mm. in the Acadian rocks. Doctor Brögger mentioned an example from Töien, Vestfossen, 10.5 by 12.5 mm.

I have not attempted any detailed description of the species, as it is so variable in form and surface markings. An attempt was made to discriminate varieties in the material from Sweden and Newfoundland, but there was such a gradation in all of the characters upon which such differentiation might rest that it was finally abandoned. Doctor Matthew considers that he has reason for establishing varieties among the New Brunswick forms. Whether these would be of value if a large amount of material were available for comparison is doubtful.

Dr. E. Kayser[a] illustrates a shell that is apparently identical with *O.* (*O.*) *lenticularis*, which occurs in the sandstone at Tilcuya, Argentine Republic, in association with *Olenus*, *Agnostus*, etc. He also illustrates on Plate I, fig. 13, a dorsal valve of a small *Orthis* that in many respects looks more like *O. lenticularis* than figs. 11 and 12. I very much doubt if they represent this species; in fact Doctor Kayser questions his identification by an interrogation mark. He says of the shell:

> Another much smaller Orthis species occurs in the fine-grained sandstones of Tilcuya, associated with Olenus, Agnostus, Arionellus, Theca, and Orthis saltensis, which has just been described. The smaller Orthis species is transversely oval in outline, with straight hinge edge, corresponding to the greatest breadth of the shell. The ventral valve is moderately arched, the dorsal somewhat less. The surface of both valves is covered with comparatively strong ribs, arranged in bundles. On the middle of the ventral valve there is an especially well-marked rib or bundle of ribs.

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[a] Paleontographica, Primordiale und untersil. Foss. Argentenischen Rep'b., p. 9, pl. I, figs. 11, 12.

To it corresponds on the dorsal valve a well-marked sinus, limited on each side by a strong bundle of ribs.

The form just described agrees in the main so well with the figures given by Salter and Davidson of the small English form identified with Wahlenberg's lenticularis, that I can hardly doubt its specific identity with the latter.

Of *Orthis* sp. he remarks:

Before me lies a cast from Tilcuya, representing a third Orthis species. It is almost equal in size to *O. saltensis*, but differs from it by its outline, which is greatly prolonged transversely, the greatest breadth at the hinge edge, and the feebly wing-like projection of the hinge corners. This last-named characteristic and the much larger dimensions distinguish this fossil also from *O. lenticularis*. The surface of the shell has been covered with very strong bundles of ribs.

Formation and localities.—Upper Cambrian. Olenus schists, Nunneburg; Olands; alum shales, Andrarum; many localities in West Gotland, Sweden.

In Norway Doctor Brögger describes it from Vestfossen in association with *Peltura scarabæoides*.

In Wales it occurs at the following localities, according to Davidson.[a]

Orthis lenticularis seems to be confined to the Upper Lingulaflags (Dolgelly groups of Belt, or upper portion of the Ffestiniog group of Sedgwick), and occurs at Penmorfa Church, near Tremadoc; near Criccieth, at Ogof-ddu Cliff, Swerny-y-Barcud, Rhiwfelyn, and in several other Welsh localities.

In New Brunswick Dr. G. F. Matthew states that it occurs in great numbers and all sizes in limestone lentiles, inclosed in the black shale of division 3a, at Germaine street, St. John.

In Newfoundland I found the separated valves covering the surfaces of shaly limestone, also in the body of the thin limestone layers, about 300 feet higher in the section than the zone of *Paradoxides hicksi*, Manuels River, Conception Bay.

The following varieties of *Orthis lenticularis* have been named by Doctor Matthew. I find essentially the same forms present in the collections from Sweden and Newfoundland. The variety *strophomenoides* does not appear to be of varietal value. Many such occur in the Swedish material.

ORTHIS (ORUSIA) LENTICULARIS ATRYPOIDES Matthew.

Orthis lenticularis var. *atrypoides* Matthew, Trans. Roy. Soc. Canada, IX, 1891, p. 48, pl. XII, figs. 11a, 11b.

Original description.—This form is comparatively smooth, though the ventral valve is sometimes concentrically wrinkled. This valve is distinguished by a median ridge and somewhat flattened sides, and the dorsal valve has an unusually deep sinus. Size of the known examples, 6 by 6 mm. and 5 by 6 mm. for the two valves.

Formation and locality.—Same as *O. lenticularis* in New Brunswick.

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[a] Brit. Foss. Brach., III, p. 232.

ORTHIS (ORUSIA) LENTICULARIS LYNCIOIDES Matthew.

Orthis lenticularis lyncioides MATTHEW, Trans. Roy. Soc. Canada, IX, 1891, p. 49, pl. XII, figs. 10a–c.

Original description.—Distinguished by its sharp, strong, radiating ribs, large umbo, and high cardinal area. In some of the larger examples the radaiting ribs become subordinate to and are replaced on the newer part of the shell by concentric striæ, reversing the usual position of the ribbed and the smooth parts of the shells of this species. Size of the valves, about 6 by 8 mm.

Formation and locality.—Same as *O. lenticularis* in New Brunswick.

ORTHIS (ORUSIA ?) EUREKENSIS Walcott.

Orthis eurekensis WALCOTT, Mong. U. S. Geol. Survey, VIII, 1884, p. 22, pl. IX, fig. 8.

Protorthis ? eurekensis HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, p. 232.

Orthis ? eurekensis SCHUCHERT, Bull. U. S. Geol. Sur. No. 87, 1897, p. 286.

General form rounded subquadrate; strongly convex. Surface marked by fine, rounded, radiating ribs, five in the distance of a millimeter. Length of ventral valve, 4 mm., width, 4.5; dorsal valve a trifle shorter.

Ventral valve with a high median fold over the umbo, that widens and flattens toward the front margin, which is arched to receive the projecting median depression of the dorsal valve. The umbo curves over to the apex, which overhangs the hinge line. Area low, and strongly inclined backward. The interior cast shows that there was a thick pseudospondylium, but no details of it are preserved. Dorsal valve with a deep, gently curved, median sinus or depression, that extends from the umbo to the front margin. In the cast strong anterior adductor muscle scars are shown on the sides of the median depression, and just back of them in the sinus what may be the smaller posterior adductor scars.

Observations.—This strongly-marked shell suggests some of the more convex shells of *O.* (*O.*) *lenticularis;* it differs in its fine ribs; deep median sinus of dorsal valve and sharp fold of ventral valve; also in the presence of a thickened shelf beneath the umbo of the ventral valve that suggests a spondylium; this character, however, is sometimes indicated in *O.* (*O.*) *lenticularis.*

Formation and locality.—Middle Cambrian. Prospect Mountain limestone just beneath Secret Canyon shale. East slope of Prospect Mountain, Eureka District, Nevada.

FINKELNBURGIA, new subgenus of, ORTHIS.

This subgenus is based upon two species that differ from *Plectorthis* in having thick shells and strongly marked vascular trunks in the ventral valve. The type of the subgenus, *F. finkelnburgi*, with its acuminate and sometimes alate cardinal extremities and subequally convex valves, is a very strongly marked type; the second species, *O.* (*F.*) *osceola*, has obtuse cardinal extremities, and most of the examples closely resemble in form *Plectorthis remnicha*. It is only when the specimens from the fine-grained sandstone of Trempealeau are studied that one finds the thick shell and strong interior markings that are unknown in species of *Plectorthis*.

This subgenus is named after Mr. W. A. Finkelnburg, of Winona, Minnesota, who has been one of the most intelligent and enthusiastic collectors of Cambrian and Ordovician fossils in Minnesota in recent years.

The species referred to *Finkelnburgia* are—

Name.	Cambrian.		
	L.	M.	U.
1. *O.* (*Finkelnburgia*) *finkelnburgi*, new species			x
2. *O.* (*Finkelnburgia*) *osceola*, new species			x
O. (*Finkelnburgia*) *osceola corrugata*, new variety			x

ORTHIS (FINKELNBURGIA) FINKELNBURGI, new species.

Shell transverse with the cardinal angle extremities acuminate and in some examples almost alate. In the ventral valve the hinge line slopes toward the beak at a low angle; in the dorsal valve it is nearly straight. There is considerable variation in the height and width of the shell, this feature depending upon the extension of the cardinal angles. The convexity of the valves is subequal. In some examples the ventral valve is much more elevated and convex than in others, and the same is true of the dorsal valve. A low, clearly defined, mesial sinus occurs on the dorsal valve, being strongest in young shells, and there is frequently a flattening of the mesial area on the ventral valve.

The surface is marked by fine, rounded, radiating costæ, crossed by concentric lines, and, occasionally ridges of growth. In a ventral valve 7 mm. in height, 11 mm. in width, there are two costæ in a distance of 1 mm.

The largest specimen of a ventral valve in the collection has a height of 10 mm. with a width of 18 mm. The average shell is less than 8 mm. in height.

The cardinal area of the ventral valve is relatively high. It extends backward over the hinge line at an angle varying from 15° to 45° from the plane of the valve. The delthyrium is of moderate width and apparently partially covered by a deltidium. The cardinal area of the dorsal valve averages about one-half the height of that of the ventral valve, although in some shells it is fully two-thirds as high. It extends backward at an angle of about 70° to the plane of the valve. It is divided midway by a strong delthyrium. None of the specimens in the collections show whether there was a chilidium present or not.

In the interior of the ventral valve the strong teeth are supported by dental plates that extend to the bottom of the valve and bound the umbonal cavity (pseudospondylium). The only traces of the vascular system are the bases of strong vascular trunks. The adductor muscle scars appear to have been carried into a very narrow space on an elevated ridge between the deep impressions made by the main vascular trunks; in another specimen the points of attachment of the muscles are well advanced into the valve.

In the interior of the dorsal valve a cast of the pseudocruralium appears to have a small, cardinal process, or callosity, but it is too doubtful to serve as basis for a statement that the cardinal process is present; there are traces of a median septum shown on the central ridge toward the center of the valve. The cardinal process occurs in the anterior half of the umbonal cavity. The casts of the interior show that the crura are short and well defined, with relatively strong dental sockets beside them. The only traces of the muscle scars observed are those of the adductor.

Observations.—The exterior surface and size of this shell recalls *O.* (*Finkelnburgia*) *osceola.* It differs, however, in the accuminate ventral angles and strongly convex dorsal valve. In form the elongate cardinal angles relate this species to *Billingsella* (*Otusia*) *sandbergi*, but in surface and interior markings it materially differs from the latter.

Formation and locality.—Upper Cambrian. St. Croix sandstone at Trempealeau, Devils Lake, Osceola Mills, Wisconsin. Minneiska, Minnesota.

ORTHIS (FINKELNBURGIA) OSCEOLA, new species.

The general form of this species is similar to that of *P. remnicha*, except that it is usually more transverse. It is a smaller shell, averaging for the ventral valve a height of 8 mm. and width of 11 mm., while *P. remnicha* averages 12 mm. in height and 14 to 16 mm. in width in the adult shell. The radiating costæ are more uniformly rounded and regular and more numerous, except when compared with the variety *texana.* The shell of *O.* (*F.*) *osceola* is thick like other forms of the genus with a result that the vascular markings are definitely outlined. In one specimen the anterior and posterior diductor scars are beautifully shown; also the large main vascular sinuses so characteristic of many species of *Billingsella.* The adductor scars, cardinal process and median septum are well brought out in a cast. Some of the dorsal valves approach quite closely to those of *P. remnicha sulcata.*

Formation and locality.—Upper Cambrian. St. Croix sandstone, Trempealeau; Menomonie, one-half mile southeast of court-house; Mazomanie; Osceola Mills; Lodi, about one-third of a mile west of railroad station, Wisconsin. Just below *Dicellocephalus minnesotensis* bed, Winona, Minnesota.

ORTHIS (FINKELNBURGIA) OSCEOLA CORRUGATA, new variety.

At two localities of *O.* (*F.*) *osceola* a few specimens occur which have strong concentric ridges formed by the piling up of lines of growth. The shell has a corrugated appearance that is very distinctive and it is designated as a variety.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Osceola Mills, Wisconsin. Just below *Dicellocephalus minnesotensis* beds, Winona, Minnesota.

PROTORTHIS Hall and Clarke.

Protorthis HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, p. 231, pl. VII A, figs. 14–21; Eleventh Ann. Rep. State Geologist New York, p. 273, pl. VIII, figs. 3–7.

Billingsella SCHUCHERT, Bull. U. S. Geol. Sur. No. 87, 1897, p. 334.

Original diagnosis.—Shells small, transversely subquadrate or semicircular. Hinge-line straight, its length being equal to the greatest width of the valves. Valves unequally biconvex, or subplanoconvex, the pedicle-valve being the larger. The cardinal area is narrow on both valves, but is higher on the [ventral] pedicle-valve, and is transected by a broad delthyrium, which is closed below by a concave plate apparently produced by the union of the dental lamellæ, which are not continued to the bottom of the valve; teeth distinctly developed. In the [dorsal] brachial valve the cardinal area also bears an open delthyrium; the dental sockets are obscure and the crural plates small; the latter appear to unite and form a low elevation across the base of the delthyrium. Cardinal process absent or rudimentary in all the specimens examined. Muscular markings in both valves extremely obscure.

Surface marked by distinct plications, with interstitial finer radii, which are crossed by delicate concentric striæ; these are usually accompanied by a low sinus and fold on the brachial and pedicle-valves, respectively; interior very finely papillose. Shell-substance fibrous and apparently punctate.

Type.—*Orthis Billingsi* Hartt. St. John group.

The characters of the St. John species are eminently comprehensive; first, the form of the shell is one more frequently met with among the strophomenids than among the orthids; the concave plate formed by the union of the dental lamellæ is never found in *Orthis* proper, though occurring in *Scenidium.* In *Orthisina* or *Clitambonites* this plate is always present, but always supported by a median septum and invariably accompanied by the convex deltidium, which, so far as known, does not exist in *Protorthis;* while in the group typified by *Orthis Pepina,* Hall (here designated by the term *Billingsella*), the convex deltidium of *Clitambonites* is present and the concave or dental plate absent. The apparent absence of a cardinal process in *Protorthis* may be due to the imperfections of the fragile shells studied. The specimens of the St. John shells are preserved as external and internal casts, and from some of these there is reason to infer that the substance of the shell was punctate.

Observations.—A study of the various species here described under the genus *Protorthis* has not given data that will add to the above generic description. All of the species have evidence of punctæ of greater or less depth on the inner and outer surfaces of the shell, but in none of them have punctæ been found that penetrated through the shell; this may be owing to the fact that all of the species are preserved as casts in the sandstone or shale, and none of them have the original shell substance, or a calcareous or siliceous replacement of it.

A careful examination of a large number of specimens of the dorsal valve fails to reveal a true cardinal process.

The genus ranges from the Middle Cambrian well up into the Upper Cambrian. The Middle Cambrian species are: *Protorthis billingsi*, *Protorthis latourensis*, *Protorthis nautes*, *Protorthis quacoensis*, *Protorthis spencei*. Upper Cambrian: *Protorthis? nunnebergensis*, *Protorthis wingi*, *Protorthis*, species undetermined.

The subgenus *Loperia* has one species *P.* (*L.*) *dougaldensis* from the Middle Cambrian.

PROTORTHIS BILLINGSI Hartt.

Orthis billingsi Hartt, Acadian Geology, Dawson, 1868, 2d ed., p. 644, fig. 223.

Orthis billingsi Walcott, Bull. U. S. Geol. Survey No. 10, 1884, p. 17, pl. I, fig. 1, 1a–d.

Orthis billingsi Matthew, Trans. Roy. Soc. Canada, III, 1886, p. 43.

Orthis ? billingsi Matthew, Trans. Roy. Soc. Canada, VIII, 1891, p. 131.

Protorthis billingsi Hall and Clarke, Pal. N. Y., VIII, Pt. 1, pp. 219, 232, pl. VII A, figs. 14–20; Eleventh Ann. Rep. State Geologist, New York, 1892, p. 273, pl. VIII, figs. 3–7.

Billingsella billingsi Schuchert, Bull. U. S. Geol. Sur., No. 87, 1897, p. 158.

The generic description follows very closely that of the type species *P. billingsi* in its main features. All of the specimens are compressed in the embedding shale, which renders it difficult to get a true conception of the convexity and forms of the valves. The outlines may be transversely quadrilateral or subsemicircular or subquadrate. Usually the area is inclined backward over the hinge line, but it may be distorted by pressure so as to appear to incline forward. Young shells have a well-defined median sinus on the ventral valve that shows as a flattened space on the larger shells. A slight sinus sometimes appears on the dorsal valve. The surface of the shell varies in the number and size of the radiating ribs; sometimes they are scarcely visible toward the cardinal margin, and in other shells they are clearly defined all over the surface; the increase in number is by bifurcation and interpolation; fine, thread-like concentric striæ and strong squamose lines of growth cross the ribs.

Ventral valve moderately convex, with the umbo and apex slightly curved over the area or erect above the area. Area appears to be slightly concave, divided midway by a triangular delthyrium, which is more or less closed by a concave plate that Hall and Clarke consider to be formed by the uniting of an extension of the dental plates or lamellæ; from the casts it appears that the teeth were well developed and supported by dental plates that united at the center opposite the delthyrium, but did not reach the bottom of the valve or a median septum; the free spondylium varied in length from a narrow rim opposite the head of the delthyrium to a plate two-thirds or more of the length of the delthyrium.

Dorsal valve uniformly and moderately convex, with the apex curved over to the edge of the low area; area divided by a broad delthyrium; casts of the interior show that the crura were strong, dental sockets shallow, and that the crural plates extended across the umbonal cavity, uniting to define what may be called a pseudocuralium. No trace of a cardinal process has been seen in a large number of casts of the interior, and Messrs Hall and Clarke did not find any in a large amount of material.

The casts of the interior show that the shell was minutely punctate, and a shell preserving some of the inner layers has every appearance of punctate structure,

Observations.—This species differs from all recognized species of the genus by its surface ribs and striæ.

Formation and locality.—Middle Cambrian. Paradoxides zone. Dark argillaceous shales of division 1c, Seeley street, St. John, Portland Brook and Ratcliffs Millstream, New Brunswick.

PROTORTHIS HELENA, new species.

This species is founded on the cast of a ventral valve associated with *Protosiphon kempanum.* The form of the spondylium and area is like that of *Protorthis latourensis*, but the smooth shell with a broad, rounded mesial sinus is unlike that species and also other species of the genus. The shell appears to have been thicker than that of *P. latourensis.* Only traces of growth lines are preserved on the cast. The ventral valve is 10 mm. long with a width of 14 mm. The cast shows that the teeth and dental plates were unusually strong.

This species differs from all others of the genus by its smooth or nearly smooth surface and strong median sinus. It suggests *Syntrophia barabuensis* at first sight, but there is no evidence of a median septum supporting the spondylium.

The specific name is that of Mrs. Walcott who collected the specimen.

Formation and locality.—Middle Cambrian. St. John formation. Kennebecasis River, St. John County, New Brunswick.

PROTORTHIS LATOURENSIS Matthew.

Kutorgina latourensis MATTHEW, Trans. Roy. Soc. Canada, III, 1886, p. 42, pl. v. figs. 18, 18a–c.

Kutorgina latourensis HALL and CLARKE, Pal. N. Y., VIII, 1892, Pt. 1, pp. 93, 95, 233, pl. IV, figs. 18, 19, 20.

Original description.—Valves narrowly semicircular, broader than long, flat; umbones low; greatest thickness in the posterior third; hinge line shorter than the width of the shell.

Dorsal valve with a distinct median depression extending from the umbo to the front margin, and with low ridges diverging from the beak toward the lateral third of the front of the valve. Umbo not elevated above the hinge area, which is exceedingly narrow or absent. Hinge line with two sharp, slightly projecting teeth near the umbo [crura?].

Ventral valve with a narrow median ridge extending two thirds of the length of the valve toward the front margin; also with a fainter ridge on each side diverging toward the lateral third of the border of the valve; umbo very low; hinge area perceptible but very narrow, longitudinally striated, and having a minute tooth on each side of the very narrow and small foraminal opening.

Surface ornamented with about forty or fifty fine, faint, radiating striæ; those of the middle fifth are close, continuous, and straight; a few on each side of these are more divergent, while those near the beak of the shell are fainter, closer than the last, and moderately arched outward toward the lateral borders. The surface of the valves is also marked by very fine but distinct concentric striæ; and at somewhat regular intervals by about twelve more distinct lines of growth. The concentric striæ are usually as distinct as the radiating. Casts of the interior of the valves exhibit a smooth surface with some irregular, sinous, radiating striæ.

Length 7 mm., width 11 mm. Length of hinge line, 8 mm.

Observations.—Doctor Matthew kindly sent me the types and cotypes of this species, and from them and collections in the United States National Museum, sufficient data was obtained to clearly show that his opinion that the species belong to *Protorthis* and not *Kutorgina* was correct. As far as known the characters of the area, teeth and free spondylium are the same as in *P. billingsi.* The smooth casts suggest *Kutorgina*[a] but the ribbed shells recall *P. quacoensis* and the area with open delthyrium and free spondylium place the species in *Protorthis.* Its very fine surface ribs differentiate *P. latourensis* from all other described species.

Formation and locality.—Middle Cambrian. St. John shales, division 1c, Portland, New Brunswick.

PROTORTHIS LÆVIS, new species.

Ventral valve transversely semicircular, moderately convex; surface of cast smooth; area overhanging the hinge line at about 30° from the plane of the margin of the valve. The cast shows a very clearly defined free spondylium. Shell about 6 mm. in width and 4 mm. in length.

This is the only representative of the genus known outside of the Atlantic basin Cambrian fauna. All other species occur in New Brunswick and Cape Breton. Its smooth surface and inclined area distinguish it from other species of the genus.

Formation and locality.—Middle Cambrian. St. Croix sandstone, one-half mile southeast of county court-house, Menominee, Wisconsin.

PROTORTHIS NAUTES, new species.

This species has the same type of punctate interior surface as *P. billingsi*, and casts of the exterior are marked by minute, closely set papillæ that are casts of the punctæ in the shell. Traces of the shell show the same type of papillæ. It is highly probable that the shell was punctate. The exterior form is like that of *P. billingsi*, but in the surface ribs it differs from the latter and other described species of the genus.

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[a] See figures 18–20, Pal. N. Y., VIII, Pt. 1, pl. iv.

A ventral valve has a length of 5 mm.; width, 8 mm. A dorsal valve, length, 7 mm.; width, 10 mm. There is considerable variation in the relative proportions between length and width.

Formation and locality.—Middle Cambrian. Dark argillaceous shales, Wasatch Range, near Montpelier, Idaho.

A similar shell occurs in the shaly limestone of the Middle Cambrian, 3 miles east of Antelope Springs, Utah.

PROTORTHIS (?) NUNNEBERGENSIS, new species.

Shell transversely semielliptical, plano-convex. Surface with very fine ribs that increase by interpolation and bifurcation; on some shells bands of slender ribs are delimited by stronger ribs, usually 2 to 5 between 2 more prominent ribs; fine concentric striæ give a crenulated aspect to the radiating ribs. Casts of the interior and exterior appear to be minutely papillose, indicating punctæ in the shell.

Ventral valve moderately convex, with the apex curved down to the margin of the area; area and interior unknown. Dorsal valve flat or very slightly concave between the umbo and margins; apex slightly elevated above the plane of the surface and cardinal line; a median sinus is present in some shells.

Observations.—It is a little hazardous to refer this species to Protorthis, as only the general form and surface are known. The nearly plano-convex valves and surface relate it more nearly to *Protorthis* than *Plectorthis*, and it does not appear to fall within *Leptæna*, *Rafinesquina*, or *Strophomena*. The specimens were collected by Mr. Von Schmalensee in a dark, argillaceous shale above the Ceratopyge limestone and below the lower graptalite shale.

Formation and locality.—Upper Cambrian. Mossebo, Nunneberg, Vestergotland, Sweden.

PROTORTHIS QUACOENSIS Matthew.

Orthis quacoensis MATTHEW, Trans. Roy. Soc. Canada, III, 1886, p. 43, pl. v, figs. 20, 20a–c.

Orthis ? quacoensis MATTHEW, Trans. Roy. Soc. Canada, VIII, 1891, p. 131.

Protorthis quacoensis HALL and CLARKE, Pal. N. Y., VIII, Pt. 1, p. 232, pl. VII A, fig. 21.

Billingsella quacoensis SCHUCHERT, Bull. U. S. Geol. Sur., No. 87, 1897, p. 159.

Original description.—A small species. Subquadrate to semielliptical in outline, broader than long, widest near or at the hinge line, which is not produced; moderately convex, highest in the posterior third, flattened toward the front and sides. Umbones not prominent.

The dorsal valve rises rapidly from the hinge line, and has but a narrow, flattened space at the angles. It is about one-third as high as it is long. The hinge plate has a narrow area, which is striated lengthwise, and bears two tooth-like processes close to the umbo, the point of which is bent down to the hinge line.

The ventral valve is somewhat more elevated than the dorsal. Hinge area triangular, sloping backward to the umbo, and bearing fine striæ parallel to the hinge line. Umbo elevated above the hinge line to a height fully equal to one-third of the length of the valve. Foramen [delthyrium] large, truncate-pyramidal in outline.

Surface of the valves ornamented by about twenty rounded plicæ, radiating [in the ventral valve] from the edge of the hinge area, opposite the foramen [delthyrium] and not from the beak alone; those on the middle fifth of each valve are crowded together, those outside of these are more prominent, and are continuous from the umbo; those toward the hinge line are faintly marked and widely separated. The radiating plicæ do not [or rarely] increase by bifurcation. Both valves bear numerous concentric striæ, and are also marked by a few distinct squamose lines of growth.

The mold or cast of the interior of the valves of this species is nearly smooth or is marked by faint radiating striæ; the margin of the mold, however, often exhibits a crenulated appearance corresponding to the plicæ of the outer surface. There is a wide, smooth median depression at the top of the mold of the dorsal valve near the umbo.

Length of the valve in *O. quacoensis*, 5 mm.; width, 8 mm.

Observations.—Doctor Matthew very kindly sent me his types of this species. A comparison of them with *P. billingsi* shows that the two species are quite distinct, and *P. quacoensis* is unlike any other shell referred to the genus.

As far as seen the free spondylium of the ventral valve is short; the teeth are clearly shown in the cast. The pseudo-cruralium of the dorsal valve is much more clearly defined than in *P. billingsi*, the area is higher, and traces of the adductor muscle scars are preserved.

Formation and locality.—Middle Cambrian. Paradoxides zone, division 1c, Portland and at Porter's Brook, St. Martins, New Brunswick.

PROTORTHIS SPENCEI, new species.

This is a strongly marked species despite the fact that only a few specimens have been found, and these are flattened in the shale. It is distinguished by its rounded, subquadrate outlines and narrow, sharp ribs with strong interspaces—six ribs in a distance of 5 mm. at the front margin. The area of the ventral valve has a broad delthyrium with a concave plate or free spondylium, covering the greater part of it. The interior surface of the shell is finely punctate. A flattened ventral valve has a length of 17 mm.; width, 18 mm.

This shell is associated with *P. nautes*. It differs from it in its larger size, sharper ribs, and broader interspaces between the ribs.

The species is named for Mr. R. S. Spence, of Montpelier, Idaho, a gentleman who made large collections from the Middle Cambrian shales of Idaho.

Formation and locality.—Middle Cambrian. Argillaceous shales, Wasatch Range, near Montpelier, Idaho. Shaly limestones, 3 miles east of Antelope Springs, House Range, Utah.

PROTORTHIS WINGI, new species.

General form transversely subelliptical. Surface marked by about 20 sharply ridged ribs with interspaces equal and usually greater than the width of the rib; shell with numerous small and many larger and scattered punctæ on the inner and outer surfaces. The largest ventral valve has a length of 6 mm.; width, 9 mm.

Ventral valve convex, elevated at the umbo and beak; area high and divided midway by a strong delthyrium which is partially closed by a concave free spondylium as in *P. billingsi*, teeth strong, dental plates extended toward the center to unite and form the free spondylium.

Dorsal valve slightly convex, with a broad median sinus that is usually bounded by one or two large ribs; casts of the interior show a narrow area, broad delthyrium, and the cast of a small, broadly triangular, elevated area opposite the umbo that probably served as the cardinal process for the attachment of the diductor muscles.

Observations.—This species is most nearly related to *Protorthis nautes;* it differs, as far as known, in the character of the interior of the dorsal valve, the large punctæ scattered among the fine punctæ, and the sharp ridged ribs. One cast of an interior of a ventral valve appears to indicate that that shell was without the free spondylium. It not infrequently occurs in *Protorthis billingsi* that the free spondylium is reduced to a narrow rim about the margin of the delthyrium, and it may be that in this shell it was absent.

The specific name is given in memory of Rev. Augustus Wing, who did so much excellent work in the vicinity of Swanton, Vermont, which was utilized by Mr. Billings and Sir William E. Logan.

Formation and locality.—Upper Cambrian. Dark argillaceous shales, about one-half mile south of Highgate Falls, Vermont.

PROTORTHIS, species undetermined.

Ventral valve convex, elevated at the umbo, apex incurved. The cast of the umbonal cavity (pseudospondylium) indicates well developed teeth and dental plates. On the cast 6 radiating ribs occur in the distance of 1 mm.; area about vertical. The surface of the cast indicates that the interior layer of the shell was finely punctate. Length of valve 4.5 mm., width 5.5 mm.

Only one specimen of a cast of a ventral valve of this shell was found. It suggests by its convexity and surface some of the more convex forms of *Protorthis quacoensis*.

Formation and locality.—Upper Cambrian. Tonto terrane. Thin bedded siliceous limestone at mouth of Kanab Canyon, Grand Canyon, Arizona.

LOPERIA, new subgenus of PROTORTHIS.

This subgenus is characterized by the form of the valves. The ventral valve is elevated at the umbo and flat or slightly concave from the umbo to the margins; the dorsal valve is strongly and regularly convex. The description of the type species, *Protorthis* (*Loperia*) *dougaldensis*, is that of the subgenus and species, as it is the only species thus far known of the subgenus.

PROTORTHIS (LOPERIA) DOUGALDENSIS, new species.

General form rounded subquadrate. Hinge line straight and shorter than the greatest width of the shell; cardinal extremities obtusely angular. Relative convexity of the valves reversed, as in *Dinorthis pectinella* of the Ordovician fauna. Surface of the dorsal valves with strong, simple, rounded ribs that increase by interpolation; fine concentric striæ and lines of growth that sometimes form ridges, cross the ribs, curving in the interspaces and over the ribs; these ribs are more prominent and numerous (30 to 40) on the dorsal than on the ventral valve; on the latter the ribs are broad, with narrow interspaces, and about 20 to 25 in number; casts of the exterior and interior surfaces have numerous fine, thickly set, elevated papillæ that appear as the casts of the punctæ in the layers of the shell; on some specimens the papillæ are cylindrical and elevated, which indicates that they penetrated deep into the shell substance. All indications point to a punctate shell; in all the material representing the species the shell has been removed by solution, only the casts of the inner and outer surfaces remaining.

The largest ventral valve in the collection has a length of 18 mm., width 25 mm.; dorsal valve, length 22 mm., width 27 mm.

Ventral valve elevated at the umbo and gently concave from the umbo to the front margin and flat to the cardinal extremities. Area relatively low and overhanging the hinge line at an angle of about 45°; it is divided midway by a broad delthyrium that is more or less closed by a deeply concave plate, across which the transverse striæ of growth of the area pass. The concave plate appears to be identical in form and position with the free spondylium of the genus *Protorthis*. A cast of the interior shows very strong teeth and supporting dental plates; the edges of the dental plates appear to be continuous with the concave plate or free spondylium.

Dorsal valve strongly and regularly convex, with a slight flattening of the median line and sometimes a shallow sinus. Casts of the interior show a strong area with a triangular delthyrium; the umbonal cavity is strongly outlined by the crural plates so as to form a pseudocruralium; crura well developed, with clearly defined teeth sockets back of them. No traces of a cardinal process have been seen in ten specimens showing fine casts of the area, delthyrium, and umbonal cavity.

Observations.—This fine species is unique among Cambrian brachiopods in having a depressed, flat, or convex ventral valve and strongly convex dorsal valve. In its punctate shell, free spondylium, and absence of cardinal process, it is allied closely to *Protorthis;* the depressed ventral valve and convex dorsal valve serve to distinguish it as a subgenus of *Protorthis*, which I have called *Loperia* in recognition of the effective work of Mr. S. Ward Loper, who collected the material representing this and many other Cambrian fossils in Cape Breton and New Brunswick.

Formation and locality.—Middle Cambrian. Division 2—probably 2b—of Matthew's section. Dougald Brook, tributary to Indian River; one-fourth mile from lower bridge, Escasonia, Cape Breton, Nova Scotia.

SYNTROPHIA Hall and Clarke.

Syntrophia Hall and Clarke, Pal. N. Y., VIII, 1892, Pt. 1, p. 270; 1893, Pt. 2, p. 216; Thirteenth Ann. Rep. State Geol. N. Y., 1895, p. 836.

Original description.—Shell transversely elongate, biconvex, with straight hinge-line, whose length nearly equals the greatest diameter of the valves; each valve medially divided by an open delthyrium. External surface smooth, with fine concentric lines visible only about the margins; the inner shell-layers show a strongly fibrous radiating structure without punctation. The pedicle valve bears a more or less clearly developed median sinus and the brachial valve a broad, indistinct fold.

On the interior the teeth are very small, lying at the extremities of the delthyrial margins and supported by dental plates, which converge and unite before reaching the bottom of the valve. Thus is formed a deep but short spondylium, which is supported, near its apical portion, by a median septum, but is free for fully one-half its length.

In the brachial valve there are also two convergent plates bounding the deltidial cavity, larger and stronger than those of the opposite valve. These plates may rest upon the bottom of the valve and, toward the posterior extremity, probably always do; but anteriorly they become free, forming a spondylium, which is supported by a median septum extending beyond the anterior edge of the plate. Thus these two valves, which are very similar in exterior, the pedicle-valve being only slightly the more convex and with a low median sinus, are also closely alike on the interior, each being furnished with a spondylium.

Type.—*Syntrophia lateralis*, Whitfield (sp.).

Observations.—Messrs. Hall and Clarke referred *Orthis barabuensis* and *Triplesia primordialis* among Cambrian species to Synthrophia and of Ordovician species, *Triplesia lateralis*, *Stricklandinia ? arethusa*, *S. ? arachne* and *Camarella calcifera*.

Orthis ? armada Billings, of the Lower Ordovician, certainly has a close resemblance in the spondylium of the ventral valve to this genus, and it may represent a radially striated form, as suggested by Messrs. Hall and Clarke.[a] Of the relations of the shells referred to *Syn-*

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[a] Pal. N. Y., VIII, Pt. 2, p. 218.

trophia, to *Stricklandinia*, they consider that the points of structure may represent the structure which is represented by the *Stricklandinias* of the later Silurian and Devonian. Mr. Billings noted the relationship existing between his *Camarella calcifera* and *Stricklandinia*.[a] It is probable that *S. arachne*, *S. arethusa*, and similar forms should be referred to a distinct genus. They are not typical *Stricklandinias*, and they differ in surface and shape from *Syntrophia lateralis*.

The Cambrian type of *Syntrophia* is *S. rotundatus* of the Upper Cambrian. It has a spondylium in each valve supported by a median septum, and a short area divided by a large open delthyrium.

The Middle Cambrian species, *S. texana*, and Upper Cambrian species, *S. abnormis* differ from the type species in having the greater portion of the bottom of the spondylium of each valve attached to the bottom of the valve, no evidence of median septum having been found except in a cast of a dorsal valve. *S. primordialis* has no median septum in the dorsal valve, in this respect resembling the dorsal valve of *Camarella volborthi*. There is considerable variation of form in the different species, but this is not much greater than the varieties of the type species, *S. lateralis*.

The species referred to the genus may be divided into two groups, the plicate and nonplicate. The plicate species begin with *S. texana*, and includes *S. abnormis*, *S. orientalis*, and *S. billingsi*, all of the Upper Cambrian. The nonplicate or smooth species are *S. alata*, *S. rotundata*, *S. barabuensis*, and *S. primordialis*, of the Upper Cambrian, and *S. calcifera*, *S. lateralis*, *S. nundina* and allied forms, of the Ordovician.

SYNTROPHIA ABNORMIS, new species.

Camerella calcifera MEEK, Sixth Ann. Rept. U. S. Geol. Sur. Terr., 1873, p. 464.

The general form varies from transverse to elongate. Valves biconvex, with dorsal very convex in some specimens. Hinge line straight. Surface marked by concentric striæ and imbricating lines of growth crossed by fine, rounded, radiating striæ and a variable number of rounded ribs; specimens occur with four ribs in the sinus of the ventral valve and four on each slope outside the sinus; in other ventral valves only a trace of ribs can be seen. On the dorsal valve there are shells without a sign of ribs, and others with a trace of rib on the median fold to three ribs on the fold and traces on the lateral slopes. The largest shell has a length of 7 mm.; width 9 mm.; there is great variation in the proportion of the length to the width.

The ventral valve has a broad, strong sinus that depresses the front of the valve; area well defined, with a large, open delthyrium. Casts of the interior of the ventral valve show a well-marked spondylium and very strong main vascular sinuses; both spondylium and sinuses recall those of *Billingsella plicatella.* Sections of the ventral valve cut across the umbo show the spondylium attached to the bottom of the valve. The flabelliform diductor and adductor muscle scars are clearly shown outside of the vascular sinuses.

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[a] Pal. Foss., I, p. 84.

Dorsal valve with an elevated median fold that gives a strong convexity to the valve; area low, with a strong, open delthyrium; the interior of the valve shows a shallow spondylium attached to the bottom of the valve posteriorly, and probably supported by a low median septum toward the front, and well defined anterior and posterior adductor muscle scars; narrow main vascular sinuses occur, and slender vascular lines radiate forward from the muscle scars.

Observations.—This species differs from all allied forms by its variation in outline, convexity, ribs and internal markings. Some shells approach closely to those of *S. texana*, but each species has a majority of shells that are quite unlike those of the other. Another point of resemblance is the form of the spondylium as shown by cross sections. A variety of *S. texana* from Cold Creek Canyon, Texas, has some shells that approach those of *S. abnormis* in the extravagant development of the fold on the dorsal valve and sinus on the ventral valve, but in other respects they differ from it. The form of the spondylium and plications or ribs, suggests the genus *Parastrophia* Hall.

Formation and locality.—Upper Cambrian. Head of Deep Creek Yellowstone National Park, Wyoming. North of East Gallatin River, near Hillsdale, Dry Creek, Gallatin Valley, Montana.

SYNTROPHIA ALATA, new species.

This species is characterized by its transverse form and extended cardinal angles. Exterior surface marked by concentric striæ and lines of growth and interior surface by fine, radiating striæ. A transverse section of the ventral valve at the umbo shows the spondylium with a strong median septum supporting it. The interior of the ventral valve was marked by two strong main vascular sinuses starting from the sides of the spondylium.

Formation and locality. Upper Cambrian. Honey Creek, Burnett County, Texas.

SYNTROPHIA BARABUENSIS A. Winchell.

Orthis barabuensis A. Winchell, Am. Jour. Sci., 2d ser., XXXVII, 1864, p. 228.

Leptæna barabuensis Whitfield, Ann. Rep. Geol. Survey Wisconsin, 1877, p. 60.

Leptæna barabuensis Whitfield, Geology of Wisconsin, IV, 1882, pp. 171, 195, pl. I, figs. 6, 7; pl. III, fig. 6.

Syntrophia barabuensis Hall and Clarke, Pal. New York, VIII, 1893, Pt. 2, p. 216.

Description (by Mr. Whitfield).—Shell of medium size or smaller, measuring about half an inch or less than half an inch along the hinge line; form semielliptical, longest on the hinge and more than half as wide again as long; extremities of the hinge often submucronate; front of the valves rounded or slightly emarginate in the middle. Ventral valve the most convex, and marked by a strong, angular mesial elevation, nearly one-fourth as wide on the front of the valve as the width of the shell; area moderately high and nearly in the plane of the valve; cardinal borders very gradually sloping from the center to the extremities of the cardinal line. Dorsal valve less convex than the opposite, and marked by a subangular mesial depression, corresponding to the fold of the opposite valve; area linear. Surface of the shell apparently smooth, or at least so far as can be determined from either the internal casts or from the matrix.

I had some doubt regarding the positive identity of this species with that described by Professor Winchell in consequence of the following remarks which occur in his description: "Surface with 16 or 18 ribs visible on the casts, the strongest of which limit the mesial sinus," and again, "apparently of the type of *Orthis biforta*." In examining a number of specimens I had not been able to detect any striæ or ribs, and felt somewhat inclined to regard it as a distinct species from that one. I have, however, through the kindness of Professor Winchell, been able to make a direct comparison with one of his original specimens, and should consider them as identical. The specimen sent me has the mesial fold (of the ventral valve) remarkably strongly defined by a depressed line on each margin, the center appearing tumid, which I think is in part due to accident. The specimen corresponds closely with the ventral valve we have figured, except in the strongly defined mesial fold.

Observations.—This is the same type of Syntrophia as *S. primordialis*. It differs in its more rounded outlines, shallow, rounded sinus in ventral valve, and usually a less pronounced fold on the dorsal valve. Evidence of a short median septum at the end of a very short spondylium in the dorsal valve is shown by one cast.

Formation and locality.—St. Croix sandstone, north end of Devils Lake near Baraboo and Trempealeau, Wisconsin.

SYNTROPHIA BILLINGSI, new species.

General form transversely subquadrate; rounded; biconvex, with the dorsal valve elevated on the median fold. Surface marked by a few imperfectly developed ribs on some shells, while others have only concentric striæ and lines of growth. Ventral valve with a relatively shallow median sinus, in which obscure, narrow ribs sometimes occur; none of the specimens in the collection show the area, but from the profile of the valve it must have been of moderate height, with the rather sharp apex curving slightly over it; a single poor cast of the interior shows the outline of a spondylium much like that of *S. primordialis;* the evidence of the presence of a median septum is a dark line in front of the end of the cast of the spondylium, which indicates that the shell substance extends down into the limestone and that it is the median septum. Dorsal valve with a small umbo and apex that extends forward into a prominent median fold that may be plicated or smooth; one partially exfoliated shell shows three plications on the fold and three or four on each lateral slope of the valve.

Observations.—This species belongs to the plicate group of the genus represented by *S. texana* and *S. abnormis*. It differs from *S.*

texana in being less convex and in having a shallower ventral sinus, less prominent dorsal fold, and more obscure plications.

The specific name is given in memory of Elkana Billings.

Formation and locality.—Upper Cambrian. In lentile of limestone interbedded in silicious shales above the Olenellus shales, 1 mile east of Parker's quarry, Georgia Township, St. Albans County, Vermont.

SYNTROPHIA NUNDINA, new species.

Triplesia calcifera WALCOTT, Mong. U. S. Geol. Sur., VIII, 1886, p. 75, pl. II, figs. 7, 8.

The nonplicate, convex species that is found in the Lower Ordovician of the western United States has usually been referred to *Camerella* or *Triplesia calcifera.* It is much like the latter, but differs in being less convex, with apex of valves less pointed and incurved.

Formation and locality.—Lower Ordovician. Pogonip formation. Spur on ridge extending out southwest from Wood Cave; lower eastern slope of ridge, east of Hamburg Ridge, facing Secret Canyon road; west side of Goodwin Canyon; base of Pogonip limestone northeast of Adams Hill, Eureka District, Nevada.

Pinkish colored limestone 30 to 75 feet above Algonkian rocks, Williams Canyon, above Manitou, Colorado.

SYNTROPHIA ORIENTALIS, new species.

This species is closely related in form and surface characters to *Syntrophia texana* and some forms of *S. abnormis.* It differs from them in details of surface ribs. On the dorsal valve there are two or three faintly defined radiating ribs on each side of the median fold, which has obscure ribs upon it. Corresponding ribs occur upon the mesial depression of the ventral valve and the side slopes adjoining the depression. The material representing it is too limited to warrant an identification with any described species. *S. orientalis* is the trans-Pacific representative of *S. texana.*

Formation and locality.—Upper Cambrian. Lower part of Chao Mi Tien (?) limestone, 2.7 miles southwest of Yen Chuang, Province of Shantung, China. Collected by Eliot Blackwelder and Bailey Willis of the Carnegie Institution Expedition, 1903.

Syntrophia, sp.—Three specimens of a ventral valve, very much like that of *S. primordialis* Whitfield, occur at the same locality as *S. orientalis.*

SYNTROPHIA PRIMORDIALIS Whitfield.

Triplesia primordialis WHITFIELD, Ann. Rep. Geol. Surv., Wisconsin, 1877, p. 51.

Triplesia primordialis WHITFIELD, Geology of Wisconsin, IV, 1882, p. 172, pl. x, figs. 1, 2.

Triplesia primordialis HALL, Pal. New York, VIII, 1892, Pt. 1, p. 271.

Syntrophia primordialis HALL and CLARKE, Pal. New York, VIII, 1892, Pt. 2, p. 218.

Original description.—Shell small, measuring less than half an inch in width; transversely oval in outline, and quite ventricose in profile; hinge line straight and about half as long as the width of the shell below; area narrow. Ventral valve with a strongly depressed, rather narrow and rounded mesial sinus. Dorsal valve with a narrow, sharply elevated fold not extending quite to the beak; side of the valve rounded. Surface smooth in the casts, but presenting the appearance of having been externally striate. Processes in the interior of the dorsal valve apparently forming a small spoon shaped pit at the beak.

Observations.—Casts of the interior show the form of the spondylium and supporting median septum in the ventral valve; also the small, short spondylium in the ventral valve, which appears to be attached to the bottom of the valve without a median septum.

This species differs from *S. barabuensis* in its smaller size, less transverse outline, and more pronounced mesial depression on the ventral valve. Examples occur of the dorsal valves of the two species that are very similar. Some of the shells approach certain forms of *S. calcifera*, but the larger number are less convex and more transverse and with more obtuse cardinal angles. A shell closely allied to *S. primordialis*, and apparently identical, occurs in the Reagan limestone. Only the exterior is known.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Taylors Falls, Adams County, Wisconsin. Abundantly at Minneiska, and more rarely at River Junction, Houston County, and near Winona, Minnesota.

Numerous examples of a closely related shell occur in the upper part of the Reagan limestone in the SE. corner, NE. ¼ sec. 2, T. 4 N., R. 13 W., 15 miles northwest of Fort Sill, Wichita Mountains, Oklahoma Territory.

A single ventral valve of the nonplicate shell with a deep sinus comes from the Upper Cambrian, Reagan limestone, Indian Territory, NW. ¼ sec. 1, T. 2 S., R. 1 E. Specimens of the ventral valve of a shell apparently identical with *S. primordialis* occur in the limestone passage beds between the Upper Cambrian and Ordovician on the north side of Tepee Creek, east side of Big Horn Mountains, Wyoming.

SYNTROPHIA PRIMORDIALIS ARGIA, new variety.

This specimen is separated as a variety of *S. primordialis* on account of its less convexity and more shallow median sinus which has three rudimentary plications in it.

Formation and locality.—Upper Cambrian. St. Croix sandstone, Reeds Landing, foot of Lake Pepin, Minnesota.

SYNTROPHIA ROTUNDATA, new species.

General form rotund, unequally biconvex; hinge line short. Surface marked by fine, concentric striæ and low, imbricating varices of growth. The longest shell observed has a width of 13 mm.; length 11 mm. Ventral valve convex at the umbo and beak, but depressed toward the front by a strong, broad, and deep median sinus. Area low, short, and divided midway by a relatively large triangular delthyrium. Transverse sections of the umbo near the beak show the cross section of a well developed spondylium supported on a medium septum. Dorsal valve about as convex as the ventral on the umbo but the strong, broad median fold makes it more strongly convex anteriorly. Cross sections at the umbo show a spondylium and supporting septum very much like that in the ventral valve.

Observations.—This species is taken as the Cambrian type of the genus *Syntrophia.* It has a spondylium in each valve supported by a median septum in the same manner as in the Ordovician type of the genus *S. lateralis.* Its rotund form, deep ventral sinus, and strong dorsal fold serve to distinguish *S. rotundata* from other species of the genus.

Formation and locality.—Upper Cambrian. Limestone on Wolf Creek, Big Horn Mountains, 14 miles west-southwest of Sheridan, Wyoming.

SYNTROPHIA TEXANA, new species.

Camerella sp.? SHUMARD, Am. Jour. Sci., 2d ser., XXXII, 1861, p. 221.

This may be called the plicate species of the group of forms referred to *Syntrophia.* It is intimately connected with the smooth forms by a series of shells that vary from 16 ribs on a valve to 1. In form *S. texana* is much like *S. abnormis;* also in the cross section of its spondylium. They differ in the extravagant development of the plications of *S. abnormis,* a feature characteristic of a large series of specimens.

S. texana occurs in great numbers in one of the upper limestone beds of Packsaddle Mountain.

The average size of the larger shell is, width, 8 mm., length 6 to 7 mm.

It is probable that this is the shell referred to by Doctor Shumard as *Camerella* sp.? He said of it—

> There are several specimens of small brachiopod in the Texas State collection from the Potsdam sandstone of Morgan's Creek, Burnet County, which appear to belong to the genus *Camerella* recently created by Mr. E. Billings. Unfortunately, however, they consist merely of detached and imperfect valves, too much weathered for satisfactory determination and description.[a]

Formation and locality.—Upper Cambrian. Packsaddle Mountain, Llano County, Texas.

SYNTROPHIA TEXANA LAEVIUSCULUS, new variety.

A variety occurs in Texas with few traces of plication in the sinus; with one, two or three strong plications on the dorsal fold, or none at all; it approaches *S. abnormis* in some of its extreme forms where the ribs are large on a prominent mesial fold; in most young shells the sinus and fold are inconspicuous, the convexity is very moderate and the shell smooth; nearly all the characters of the adult are missing.

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[a] The Primordial Zone of Texas, with descriptions of New Fossils, American Jour. Sci., 2d ser., XXXII, 1861, p. 221.

A group of young shells from Honey Creek shows only the smooth, slightly convex forms with only slight ventral sinus and dorsal fold. One larger shell associated with the young shells has a relatively deep sinus and a trace of a plication.

Formation and locality.—Upper Cambrian. Cold Creek Canyon and Honey Creek, Burnet County, Texas.

Genus POLYTOECHIA Hall and Clarke.

Polytoechia Hall and Clarke, Pal. N. Y., VIII, 1892, Pt. 1, p. 239, pl. vii a, figs. 26–30.

Original diagnosis.—Shell small, subtrihedral in contour. Hinge line straight, about equaling the diameter of the shell. Pedicle [ventral] valve with a high, nearly vertical cardinal area marked with oblique striations parallel to the lateral margins. Delthyrium covered by a narrow, convex plate; the presence of a foramen not determined. On the interior the dental lamellæ are widely separated and descend along the umbonal cavity for a short distance vertically, thence bending sharply inward and meeting at a low angle in the median line, thus forming, with the deltidium, a conspicuous subrostral vault. This inner spoon-shaped plate, spondylium, is supported by a stout median septum, and two smaller lateral septa, which meet at the lines of angulation; the former of these extends for the entire length of the plate, while the latter is free from the accessory septa near its anterior edge. The umbonal cavity of the valve is thus divided into five chambers, and in the lateral chambers there is still another septum, lower than the rest and not extending to the spondylium. The brachial [dorsal] valve is shallow and depressed-convex, with a narrow cardinal area. The delthyrium is very broad, with a partially developed covering, the dental sockets are widely separated, the crural plates narrow and nearly parallel to the hinge line. The cardinal process is simple, linear and quite prominent, and at its union with the crural plates is a subtriangular thickening which is supported by a low median septum. Surface covered with fine, elevated radiating striæ, without evidence of median fold and sinus.

Type.—*Hemipronites apicalis*, Whitfield.

Observations.—This genus is known only in the Lower Ordovician strata of Vermont and Montana. The type species is described as having a convex deltidium covering the delthyrium of the ventral valve; this character and the additional septa supporting the spondylium and cruralium are the distinguishing characters between it and *Syntrophia*. There is still less difference from *Clitambonites*, as in the latter the convex deltidium is present. It is quite probable that representatives of the genus will be found in the Upper Cambrian formations when they are searched more thoroughly.

POLYTOECHIA ? MONTANENSIS, new species.

This shell was placed with *Camerella calcifera* until sections were made showing the numerous septa supporting the spondylium and cruralium. In general form it is close to *Syntrophia rotundata*, differing in the numerous supporting septa of the spondylium which divide the umbonal cavity into fine chambers. The material available for study does not show the area in very good preservation; a delthyrium exists in the area of the ventral valve which is all that can be said.

This species appears to be a direct descendant of the smooth, convex forms of *Syntrophia* like *S. rotundata.*

Formation and locality.—Lower Ordovician. Limestone east side of Gallatin River above Gallatin City, Montana.

SWANTONIA, new genus.

The description of the type species includes that of the genus, as there is only one other species now referred to the genus and that is very imperfectly known.

Type.—Camarella antiqua, Billings.

SWANTONIA ANTIQUATA, Billings.

Camerella antiquata BILLINGS, Pal. Foss., I, 1861, p. 10, fig. 13.

Camerella antiquata BILLINGS, Geol. Vermont, II, 1861, p. 949, fig. 353.

Camarella antiquata BILLINGS, Geol. Canada, 1863, p. 284, fig. 290.

Camarella antiquata WALCOTT, Bull. U. S. Geol. Survey, No. 30, 1886, p. 122, pl. VII, fig. 8.

Camarella antiquata WALCOTT, Tenth Ann. Rept. U. S. Geol. Survey, 1891, p. 613, pl. LXXII, fig. 3.

Camarella? antiquata HALL and CLARKE, Pal. New York, VIII, 1893, Pt. 2, p. 220.

Protorhyncha? antiquata SCHUCHERT, Bull. U. S. Geol. Survey, 1897, No. 87, p. 334.

Ventral valve ovate, moderately convex; apex pointed and incurved over the area nearly to the plane of the margins of the valve; surface marked by from 8 to 12 or more rounded ribs that extend back well toward the apex; a slight flattening of the median portion suggests that a shallow median sinus may be found on old shells. The shell illustrated has a length and width of 11 mm.

A cast of the interior of a ventral valve shows no traces of muscle scars or vascular markings; two strong teeth are indicated, also a narrow, strong, concave shelf or area; the area shelf is free from contact with the bottom of the valve, a recess or chamber existing beneath it.

Observations.—The area or shelf may be considered a short, free spondylium, corresponding to the short spondylium of *Camarella volborthi* as illustrated by Hall and Clarke.[a] It differs from the latter in the absence of a supporting median septum.

Swantonia is closely related to *Camarella*, but it differs in the absence of a supporting median septum beneath the spondylium of the ventral valve. No specimens of the dorsal valve have been observed.

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[a] Pal. New York, VIII, Pt. 2, pl. LXII, fig. 18.

Formation and locality.—Lower Cambrian, in sandy shales with *Olenellus thompsoni*, *Kutorgina cingulata*, and *Iphidea labradorica*. One and a half to 2 miles east of Swanton, Vermont.

SWANTONIA WEEKSI, new species.

This shell has the general form of *Swantonia antiquata*, but the ribs are finer, more numerous, and crossed by fine, sharp concentric striæ. Only the exterior of the ventral valve appears to be represented in the collection made by Mr. F. B. Weeks.

Formation and locality.—Lower Cambrian. In an argillaceous shale with fragments of Olenellus, *Kutorgina spinosa*, etc. Three miles north of Volcaldi Spring, or 4 miles northwest of Drinkwater mine, Silver Peak District, Nevada.

OBOLELLA ASIATICA, new species.

General form broad, oval, with the ventral valve showing a tendency to become bluntly acuminate. Valves gently convex. Surface of shell marked by concentric, raised lines of growth that form the front edge of narrow lamellæ of varying width; the raised lines are highest on their front side, which gives an imbricated appearance to the surface; fine concentric striæ occur on the interspaces between the raised lines. Shell strong, calcareous.

The specimens occur in a compact, bluish-gray oolitic limestone. None of them show the area or interior of the valves. The reference to Obolella is based on the general form and calcareous shell. The shells vary in size from 3 mm. to 5 mm.

Obolella asiatica may be compared with young shells of *O. crassa*. Its broadly elliptical form and slight convexity distinguish it from other species of the genus.

It may be that if material is found showing the interior of the valves the generic reference will be changed; but with the data now available the reference is to *Obolella*.

The geological horizon is in some doubt as the specimens were found in a block of river drift limestone. The associated fragments of trilobites are two indefinite for determination. *Obolella* is a Lower Cambrian genus as far as known, and other blocks of river drift limestone at the same locality contained fragments of *Olenellus*, so the reference of the species is made to the Lower Cambrian.

Formation and locality.—Lower Cambrian. River drift on the Lan Ho River, 1 mile south of Chen Ping Hsien, Southern Shensi, China.

Collection of Bailey Willis and Eliot T. Blackwelder, Carnegie Institution of Washington, expedition to China.

ACROTRETA ATTENUATA Meek.

Acrotreta attenuata MEEK, Sixth Ann. Rep. U. S. Geol. Sur. Terr., 1873, p. 463.

Acrotreta gemma WALCOTT, Monog. U. S. Geol. Sur. VIII, 1884, p. 17; Bull. U. S. Geol. Sur. No. 30, 1886, p. 98; Monog. U. S. Geol. Sur., XXXII, 1899. Pt. 2, p. 449.

The species is characterized by its elevated ventral valve and narrow, incurved false area. Some of the forms of *A. idahoensis alta* look like *A. attenuata*, but the false area is different. *A. kutorgai* has a somewhat similar false area and elevation, but it is a less robust shell and the apex of the ventral valve is nearer the posterior margin. The reference to *A. gemma* is explained under the description of the genus. A shell with a distinctly marked false pedicle groove in the ventral valve, occurs in the *Bathyuriscus wheeleri* zone of the Middle Cambrian of Utah that shows fine interiors of both valves. The interiors of the ventral valve are much like those of *A. kutorgai*.

Formation and locality. Middle Cambrian. Flathead terrane. Valley of East Gallatin River near Hillsdale. North of Gallatin River. Base of limestone series resting on Flathead shales, Beaver Creek, 6 miles north of York, Big Belt Mountains, Montana. On divide at head of Sheep Creek near the north end of Teton range, Wyoming. South slopes of Marjum Pass, west of divide, House range, Utah. Above *Bathyuriscus wheeleri* zone 2½ miles east of Antelope Springs, House range, Utah.

Upper Cambrian. In the Hamburg shale, a little south of the Hamburg mine, Eureka district, Nevada.

ACROTRETA ATTENUATA, variety?

A shell with a distinctly marked false area is separated as a variety of *A. attenuata*. It is associated with the type specimens in the east Gallatin Valley.

ACROTRETA BISECTA Matthew.

Acrotreta baileyi MATTHEW? Trans. Roy. Soc. Canada, IX, 1892, p. 43, pl. XII, fig. 7d.

Acrotreta bisecta MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1901, p. 275, pl. v, figs. 5a–g; IV, 1902, pl. v, p. 394; pl. XVI, figs. 2, 2a–g.

Acrotreta sipo MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, IV, 1902, Pt. 5, p. 406, pl. XVIII, figs. 1 and 2.

Acrotreta sipo MATTHEW, Geol. Sur. Canada, Rep. Cambrian rocks, Cape Breton, 1903, p. 185, pl. XVIII, figs. 1 and 2.

Acrotreta bisecta MATTHEW, Geol. Sur. Canada, Rep. Cambrian rocks, Cape Breton, 1903, p. 186, pl. XI, figs. 5a–g.

Nearly all the ventral valves of this species are more or less compressed in the shale, thus decreasing the true elevation. Mr. Matthew illustrates a pointed, high ventral valve, but does not state whether the figure is diagramatic. Some of the casts in the shale indicate a sharply conical ventral valve. When the apex is broken off the cast of a median apical callosity is seen, with the base of the cast of a medium-sized foraminal tube. The cardinal scars are small and nearly concealed by the cast of the strong main vascular sinuses. There is considerable range of variation in the size and length of the median ridge of the dorsal valve. One specimen shows a strong median ridge, cardinal and central scars, and deeply excavated false deltidium. Surface marked by fine concentric striæ and lines of growth and very fine undulating striæ, that give the concentric striæ a fretted appearance when examined by a strong lens.

The most nearly related species appears to be *A. sabrinæ* of the Shineton shales. Dr. G. F. Matthew has described a shell as *Acrotreta sipo* that occurs with the Asaphellus fauna. I am unable to detect any specific differences between it and *A. bisecta* from the same area.

Formation and locality.—Upper Cambrian. Barrachois Glen, 4 miles south of Little Bras D'Or Lake, Cape Breton. Mr. Matthew's types came from McLeod Brook, Cape Breton, Nova Scotia, and he also identifies it from division C. 3c., at Navy Island, St. John Harbor, New Brunswick. Mr. S. Ward Loper found many specimens at several horizons in the shales on both sides of the Barrachois River near the Boisdale road and for some distance north, also on the east branch of the Barrachois River, Cape Breton, Nova Scotia. On the west bank it is associated with *Asaphellus homphrayi* var. as identified by Dr. G. F. Matthew.

ACROTRETA? CANCELLATA, new species.

The only specimen of this species in the collection has more the form of *Iphidea* than *Acrotreta*. In its overhanging false area it suggests *Acrothyra*. Whatever the genus may be to which it belongs, its cancellated surface serves to distinguish it from forms to which it might otherwise be compared. This surface is formed by very fine, raised, concentric lines or ridges of growth, crossed by sharp radiating lines which are seen only between the concentric lines.

Formation and locality.—Ordovician Pogonip limestone, Round Top Mountain, Eureka District, Nevada.

ACROTRETA EGGEGRUNDENSIS Wiman.

Acrotreta eggegrundensis Wiman, Bull. Geol. Institute, Upsala, No. 2, VI, 1903, Pt. 1; Studien Nordbaltische Silurgebiet, p. 55, pl. II, figs. 23–29.

This species is of a characteristic Middle Cambrian type of Acrotreta, represented in America by *A. idahoensis* and *A. kutorgai*. The surface is marked by unusually strong lines and ridges of growth and the false area is well defined. It is quite distinct from other species of the genus in European formations.

Formation and locality.—Middle? Cambrian. Coarse grained, somewhat friable, glauconitic sandstone. Drift bowlder No. 3 on Eggegrund Island, North Baltic region, Sweden.

For note on the geological horizon see description of *O.* (*Westonia*) *bottnica.*

ACROTRETA EMMONSI, new species.

Only the interiors of the two valves are known of this species. One of them shows the distinct character of the vascular markings and muscle scars. The only shell with which it can be compared is the dorsal valve of *Acrotreta idahoensis.* At first sight I was inclined to refer this shell to *Obolella*, but its corneous test, cardinal muscle scars, and absence of area of the *Obolella* type, prevented. Fragments of *Olenellus* occur in the layer of limestone from which the specimens were obtained.

The specific name is given in memory of Dr. Ebenezer Emmons, who studied and wrote of the Bald Mountain section.

Formation and locality.—Lower Cambrian. Limestone interbedded in shales on upper part of the west slope of Bald Mountain, township of Greenwich, Washington County, New York.

ACROTRETA LIANI, new species.

Shell small, about 1.5 mm. in diameter; outline of aperature subcircular, the posterior side being slightly transverse. Ventral valve conical with the apex a little in advance of the posterior margin; false area indefinite, except for a rather strong, flat furrow that extends from the apex to the margin; the elevation of the valve is about two-thirds its diameter at its aperature. Dorsal valve slightly convex, apex marginal. Surface of shell marked by fine, concentric striæ and lines of growth that on the dorsal valve tend to form low ridges toward the outer margins.

Observations.—This species is the representative of the American *Acrotreta idahoensis sulcata.* It has the same type of false area, and the ventral valve is of average height. The specific name is given in recognition of Lian, Mr. Willis's faithful Chinese interpreter.

Formation and locality.—Middle Cambrian. Chang Hsia limestone in upper oolitic portion, Chang Hsia, Shantung, China.

Collections of Mr. Eliot Blackwelder, Carnegie Institution of Washington, expedition to China.

ACROTRETA NEBOENSIS, new species.

This is one of the *Acrotreta idahoensis* forms of the genus. The ventral valve is moderately elevated, the apex projecting slightly over the nearly vertical false area. The latter is marked midway by a very narrow false pedicle furrow.

The transverse dorsal valve has a strong median depression, which starts on the umbo and widens out rapidly toward the front. The surface of the shell is marked by concentric ridges and lines of growth and very fine concentric striæ.

This species differs from other described forms in the strong median depression of the dorsal valve.

Formation and locality.—Middle Cambrian. Limestone above quartzite, Mount Nebo Canyon, 3 miles southeast of Mona, Utah.

ACROTRETA NOX, new species.

This minute shell, 1 mm. in length, is characterized by its low ventral valve, nipple-like apex, and apparently smooth surface.

Formation and locality.—Upper Cambrian. Argillaceous shales in St. Croix sandstone, 8 miles east of Baraboo, Wisconsin.

ACROTRETA PACIFICA, new species.

Ventral valve a high cone, with the apex a little in advance of the posterior margin; base circular, with the exception of a slight flattening on the posterior side; apex acute and pointing upward; false area only a slight flattening of the shell from the apex to the margin. The largest ventral valve has a diameter and height of about 1.5 mm. Surface marked by fine concentric striæ that continue without noticeable deflection across the false area.

Observations. Only two specimens of the ventral valve of this species occur in the collection. One of these has a slightly transverse, broadly oval base, and a more definite false area. The species is closely related to *Acrotreta idahoensis alta*, except that the ventral valve is not quite as elevated.

Formation and locality.—Middle Cambrian. Chang Hsia limestone at Yen Chuang and 3½ miles southwest of Yen Chuang; 3 miles southwest of Yen Chuang in limestone nodules at base of green shale phase of the Chang Hsia oolitic formation; Shantung, China.

Collections of Mr. Eliot Blackwelder, Carnegie Institution of Washington, expedition to China.

ACROTRETA SHANTUNGENSIS, new species.

Shell small. Ventral valve a low cone with the apex a little forward of the posterior margin, which is slightly flattened; apex minute, directed backward and projecting slightly over the faintly defined false area. The cast of the interior shows that the apical callosity was rather large and the main vascular sinuses well defined on each side of it; the cardinal scars are small and not prominent.

Dorsal valve slightly convex; apex marginal; surface marked by a rather broad shallow median depression that begins on the umbo and gradually widens toward the front margin. The interior of the dorsal valve has a strong median ridge extending from the posterior margin two-thirds the distance toward the front. A small elevated cardinal scar occurs on each side of the median ridge a little in advance of the posterior margin. Main vascular sinuses rather strong; they start beneath the apex and extend forward a short distance from the outer lateral margin of the shell. Surface marked by fine concentric striæ and lines of growth.

Observations.—This shell in size and general form is closely related to *Acrotreta microscopica* of the Middle Cambrian fauna of the United States. It occurs quite abundantly in a chocolate-colored limestone associated with *Obolus* (*Lingulella*) *chinensis.*

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Yen Chuang and 2½ miles south of Yen Chuang, Shantung, China.

A shell apparently identical with *A. shantungensis* was collected from a fine-grained bluish-black limestone river drift block 1 mile south of Chen Ping Hsien, on the Lan Ho River.

Collections of Mr. Bailey Willis and Mr. Eliot Blackwelder, Carnegie Institution of Washington, expedition to China.

ACROTRETA SPINOSA, new species.

The general form of this shell is much like that of *Acrotreta idahoensis.* It differs in having a straighter posterior margin. The main character of the species is the spinose outer surface. The surface is marked by fine concentric lines of growth at irregular intervals, with numerous, very fine, thread-like striæ between. On some shells radiating, more or less irregular, fine, rounded ridges occur that are formed by the elevated elongate spine bases. When these elongate bases are irregularly arranged, the radiating ridges are not present. Owing to their minute size the spinules are rarely seen.

Formation and locality.—Upper Cambrian, Hamburgh shale. Hamburgh Ridge; east side of Sierra Canyon opposite Pinnacle Peak and also opposite the Jackson Mine, Eureka District, Nevada.

ACROTRETA UPLANDENSIS Wiman.

Acrotreta uplandensis WIMAN, Bull. Geol. Institute, Upsala, No. 2, VI, 1903. Pt. 1; Studien Nordbaltische Silurgebiet, p. 54, pl. II. figs. 15–18.

This species recalls at once *A. idahoensis sulcata.* It differs from it in having a broader false area. The surface is marked by fine thread-like striæ that cross the false area and false pedicle groove.

Formation and locality.—Middle ? Cambrian. Gray bituminous sandstone in drift bowlder No. 2 on Biludden Island. Also in glauconitic sandstone, bowlder No. 1, at Höganas Commune of Börstil, Sweden.

ACROTRETA UPLANDICA LIMONENSIS Wiman.

Acrotreta uplandica limonensis WIMAN, Bull. Geol. Institute, Upsala, No. 2, VI, 1903, Pt. 1; Studien Nordbaltische Silurgebiet, p. 54, pl. II, figs. 19–22.

Doctor Wiman states that this species is quite like *A. uplandica*, but lower, as the height is only one-third of the diameter. It is so close in all other respects that I do not think that more than a varietal value should be given to the differences mentioned.

Formation and locality. Middle ? Cambrian. Bluish calcaneous sandstone. Drift bowlder, Limon Island, Gefle Bay, Sweden.

ACROTHYRA MINOR, new species.

This species differs from others referred to the genus by its broad form and very strong vascular sinuses. The elevated callus between the sinuses is high and oval in outline, somewhat like that of *Acrotreta inflata*. It may be that this species belongs to a different genus, but with the material available for study it is referred to *Acrothyra* on account of its low, overhanging false area and elongate visceral area.

Formation and locality.—Middle Cambrian. Two miles southeast of Malad City, Idaho.

ACROTHELE (?) MINUTA, new species.

Shell minute, 1.5 mm. in diameter, subcircular in outline, gently convex, with a slight median depression from the umbo to the anterior margin; back of the umbo there is a sharp median depression between minute ridges, on each of which there are two points or nipples. Surface marked by fine concentric striæ. Substance of shell apparently phosphatic.

This interesting little species is represented by a single specimen. The generic reference is somewhat doubtful.

Formation and locality. Middle Cambrian. Chang Hsia limestone. Two and one-half miles southwest of Yen Chuang, Shantung, China.

Collection of Eliot Blackwelder, Carnegie Institution of Washington, expedition to China.

ACROTHELE RARUS, new species.

Of this shell only the interiors of the valves are known. Shells of average size are about 3.5 mm. in diameter. The outline of the valve is subcircular, the transverse diameter being slightly more than the length of the valve. The interior of the ventral valve shows that the valve was moderately convex with a perforated apex about one-half a millimeter from the posterior margin. A short, broad median ridge extends for a short distance in front of the foraminal opening and short, narrow ridges extend obliquely forward from each side of the opening. What may be lateral muscle scars occur close to the postero-lateral margins. In the dorsal valve a strong median ridge extends from the posterior margin to the center of the valve; this ridge is angular at the summit and broadest toward its anterior end. A vascular sinus starts on each side of the base of the median ridge and extends obliquely forward.

The dark interior surface of the valves is marked by concentric lines that give a somewhat laminated appearance to the surface. From the manner in which the shell adheres to the limestone matrix, it is probable that its outer surface is roughened by raised lines, somewhat as on *Acrothele subsidua*.

The data for comparison of this species with described species from America and Europe are too limited to be of value. A comparison with *Acrothele (mobergia) granulata*, Redlich, of the Salt Range, India, shows a strong similarity in the interiors of the dorsal valves; but I do not think it is probable that the two forms are specifically identical, as the interiors of the valves of several species of *Acrothele* appear very much alike.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Three miles south of Kao Chia Pu, Shantung, China.

Collected by Mr. Eliot Blackwelder, of the Carnegie Institution of Washington, expedition to China.

IPHIDELLA, new genus.

Iphidea BILLINGS, Can. Nat., new ser., VI, 1872, p. 477, fig. 13, and of AUTHORS.—Not *Iphidea* BAYLEY, 1865.

For synonomy and description of Iphidea=Iphidella, see Proc. U. S. Nat. Mus., XIX, 1897, p. 707.

IPHIDELLA MAJOR, new species.

Ventral valve subconical, with the apex slightly in front of the posterior margin. A minute beak appears to incurve over the pseudodeltidium. Cardinal slope rather abruptly rounded so as to indicate a rather narrow area. Pseudodeltidium broad, convex, with its lower margin arched so as to leave a space between it and the hinge line of the shell. Dorsal valve slightly convex, with a narrow area and broad, apparently open delthyrium.

Surface, as far as can be determined from the badly preserved material, marked by very fine concentric striæ.

The material representing this species is more or less compressed and distorted in the argillaceous shales in which it occurs. In general form it is not unlike that of *I. labradorica*, but it differs in its nearly smooth surface and the position of the apex. From *I. superba* it differs in its much greater size, although resembling it in the narrow and perfectly defined area of the ventral valve, and the large, broad, convex pseudodeltidium.

Formation and locality.—Lower Cambrian. Argillaceous shales, 4 miles south of Helena, Shelby County, Alabama.

IPHIDELLA NISUS, new species.

Ventral valve rather low, with the apex overhanging the posterior margin. Surface marked by very fine lines of growth with still finer bands of striæ between them. About 10 very fine, radiating ridges extend from near the apex to the front and lateral margins.

This little shell is represented by a single specimen of the ventral valve from the conglomerate limestones near Bic. The associated fauna included fragments of *Olenellus*.

I was at first inclined to refer this shell to *I. sculptilis* or *I. peali;* but the overhanging apex and strongly marked surface, and the fact that there is an interval of 2,000 miles between the species, led me to separate them. Stratigraphically the two latter species occur in the Middle Cambrian and *nisus* in the Lower Cambrian. I think the two forms forms should not be included in one species.

Formation and locality.—Lower Cambrian. In a bowlder of the limestone, 2 miles west of Bic Station, Province of Quebec, Canada.

IPHIDELLA, species undetermined.

Iphidea, sp. undet. WALCOTT, Mong. U. S. Geol. Sur., XXXII, 1899, p. 449, pl. LX, fig. 6.

Dorsal valve, semicircular, slightly convex. Hinge line somewhat shorter than the width of the shell below; nearly straight, the rostral angle about 180°. Beak small, not elevated. Surface ornamentation consists of extremely fine radiating and undulating concentric striæ that can be seen in detail only with a strong magnifying glass. Shell substance horny.

This form is associated with *I. sculptilis* and, judging from external characters, is closely related to it. The surface ornamention is of the same character, and in the absence of the ventral valve it is difficult to distinguish any specific characters on which to base a new species, although the shell is much larger than that of typical *I. sculptilis.*

Formation and locality.—Middle Cambrian. Flathead terrane (lowest fossiliferous bed); Crowfoot section, Gallatin range, Yellowstone National Park, Wyoming.

IPHIDELLA LABRADORICA ORIENTALIS, new variety.

Only one dorsal valve of this shell occurs in the collection. Its general form and surface characters are very much like those of *Iphidella labradorica swantonensis*. The varietal name is given more on account of the fact that this shell occurs in China and the variety *swantonensis* on the eastern side of the North American continent than from any marked differences between the shells from the two localities. It may be that with a good series of shells from China differences would be found that are not to be determined with only the single shell for comparison.

Formation and locality. Middle Cambrian. Chang Hsia oolitic limestone, Yen Chuang, Shantung, China.

Collections of Mr. Eliot Blackwelder, Carnegie Institution of Washington, Expedition to China.

IPHIDELLA LABRADORICA UTAHENSIS, new variety.

The general form of this variety is much like that of *Iphidella labradorica.* It differs from it in the fine thread-like concentric striæ of the outer surface, in this respect approaching *I. alabamaensis* and *I. superba.*

Formation and locality.—Middle Cambrian. Concretionary limestone above quartzitic sandstone, Ophir City, Oquirrh Range, Utah.

IPHIDELLA PANNULA MALADENSIS, new variety.

IPHIDELLA PANNULA OPHIRENSIS, new variety.

In collections from the Middle Cambrian limestones of northern Utah and southern Idaho, material has been selected for illustration which represents variety of form and surface markings of *Iphidella pannula* that might be given specific names were it not for the intermediate phases which occur at the same locality with the varieties. The specimens from near Malad City, Idaho, show a wide variation in outline and surface. Another series from near Ophir City, Utah, illustrate the entire evolution of the "pannula" type of surface, from the concentric striæ to the fine network of oblique, raised lines dividing the surface into minute, diamond-shaped depressions. In some examples the ridges are so sharp and clear that the surface has a honeycomb-like appearance.

For convenience of reference the species might be subdivided into three varieties:

Variety A.—Surface with pore-like pits, formed by obliquely crossing, elevated lines.

Variety B.—Surface with elevated, sharp ridges that give it an irregular honeycomb-like appearance.

Variety C.—Surface formed by raised, concentric lines and ridges that inosculate and become more and more irregular until a typical surface represented by variety A is developed.

The first variety, A, is typical of the species. For the second variety the name *maladensis* is proposed, and for the third variety the term *ophirensis.*

Genus KUTORGINA Billings.

Kutorgina Billings, Pamphlet; and Geol. Vermont, II, 1861, p. 948, footnote, figs. 347–349; Geol. Surv. Canada, Pal. Foss., I, 1865, p. 9, figs. 8–10.—Davidson, Brit. Foss. Brach., III, 1871, p. 342.—Dall, Bull. U. S. Nat. Museum, VIII, 1877, p. 40.—Walcott, Bull. U. S. Geol. Survey, No. 30, 1886, p. 101.—Beecher, Am. Jour. Sci., 3d ser., XLI, 1891, p. 345.—Hall and Clarke, Pal. New York, VIII, 1892, Pt. 1, pp. 90, 166, 183; Eleventh Ann. Rept. New York State Geologist, 1894, p. 247, pl. iv, figs. 11–13.

Mr. Billings proposed the genus *Kutorgina* in a footnote accompanying the description of the type species *K. cingulata*. He says:

> Since the above was written I have examined many casts of the interior of this species, and am inclined to the opinion that it is generically distinct from *Obolella chromatica*. From the very considerable elevation of the beak the dorsal valve must have an area and probably a foramen. In one specimen there are two large oval impressions faintly impressed, but still distinctly visible. There is no trace of the lateral scars; and the form, notwithstanding the characters of the surface, conveys the idea of an Orthisina. Should, upon further examination, my suspicions turn out to be well founded, I shall call the genus *Kutorgina*, after the celebrated European naturalist, Kutorga.

From our present information of the genus the following diagnosis is prepared:

Shells inequivalve, transverse or elongated. Ventral valve convex, with apex marginal or incurved over the pseudoarea. Cardinal area rudimentary, without delthyrium or well-defined pseudodeltidium. The latter usually extends one-half the distance from the apex to the plane of the posterior margins of the valve. Interior of the ventral valve with well-defined main vascular sinuses, with a visceral area between the sinuses. Dorsal valve flat or slightly convex, rising to a small, elevated umbo; apex marginal and usually pointing upward; cardinal area short, rudimentary, and without well-defined pseudodeltidium. Interior of ventral valve with median septum between the central and posterior lateral muscle scars.

Observations.—The short cardinal areas of the valves leave a broad open space between them for the passage of the pedicle. The areas are more than the reflected posterior margins of the valves, as they have transverse lines of growth and a suggestion of a pseudodeltidium. These features are more rudimentary than in *Iphidella*. *Kutorgina* includes the larger calcareous shells, and *Iphidella* the somewhat more specialized, smaller, corneous shells. The exterior form of the valves of *Kutorgina* suggest *Nisusia festinata*, with which the type species, *K. cingulata*, is associated in Vermont and at Bic Harbor.

The following species are now referred to *Kutorgina:*

K. cingulata Billings, *K. perugata* Walcott, *K. sardiniaensis* Walcott, and *K.* sp. undet. All the species are from the lower Cambrian horizon, with the possible exception of *K. sardiniaensis*.

Of species heretofore referred to the genus the following disposition is made:

K. labradorica Billings=*Iphidella*.
K. labradorica swantonensis=*Iphidella*.
K. latourensis Matthew=*Protorthis*.
K. minutissima Hall and Whitfield=*Iphidella sculptilis*.
K. pannula White=*Iphidella*.
K. prospectensis Walcott=*Iphidella*.

K. sculptilis Meek = *Iphidella.*
K. stissingensis Dwight = *Iphidella.*
K. whitfieldi Walcott = *Billingsella.*

KUTORGINA CINGULATA Billings.

Obolella (Kutorgina) cingulata BILLINGS, Geol. Vermont, II, 1861, p. 948, figs. 347–349; Pal. Foss., I, p. 8, figs. 8–10.

Obolella cingulata BILLINGS, Geol. Canada, 1863, p. 284, fig. 287.

Obolella? phillipsi HOLL, Quart. Jour. Geol. Soc., XXI, 1864, pp. 101, 102, figs. 10a, b.

Kutorgina cingulata DAVIDSON, Geol. Mag., V, 1868, p. 312, pl. XVI, fig. 10; Brit. Sil. Brachiopoda, 1871, p. 342, pl. L, fig. 25.

Kutorgina cingulata WALCOTT, Bull. U. S. Geol. Survey, 1886, p. 102, pl. IX, fig. 1.

Kutorgina cingulata BEECHER, Amer. Jour. Sci., 3d ser., XLI, 1891, p. 345.

Kutorgina cingulata WALCOTT, Tenth Ann. Rept. U. S. Geol. Survey, 1891, p. 609, pl. LXIX, fig. 1.

Kutorgina cingulata HALL and CLARKE, Pal. New York, VIII, 1892, Pt. 1, p. 92, figs. 47–49; pl. IV, figs. 10–17.

Kutorgina cingulata VON TOLL, Mem. de l'Acad. Imp. des Sci. de St. Petersburg, VIII ser., 1899. I, Beit. zur Kenntniss des Siberischen Cambrium, p. 26, pl. I, fig. 28.

General form transversely or longitudinally oval; biconvex, with the ventral much more convex than the dorsal valve. Surface marked by concentric lines and ridges of growth and the edges by imbricating lamellæ of growth. Shell substance calcareous and fibrous. The shell is formed of a thin, dark, compact outer layer and a thick, fibrous, calcareous inner layer. It is possible that the thin outer layer is chitinous, but it does not appear to be so. The L'Anse au Loup and Bic Harbor shells average about 15 mm. long by 17 mm. in width. At the Swanton locality, in Vermont, ventral valves occur 24 mm. in height and with a width of 30 mm., and one large dorsal valve is 20 mm. in length with a width of 30 mm.

Ventral valve in young shells moderately convex, becoming more and more convex with increase in size and age. In young shells the slope from the front margin to the apex is nearly straight, and the apex terminates at the posterior edge of the valve above the more or less elevated pseudodeltidium. In old shells the curvature from the front to the apex is nearly a semicircle, and the apex terminates in a pointed beak overhanging the pseudodeltidium. A mesial sinus of varying strength occurs on many shells, and in others it is entirely absent. The pseudo area is concave on the outer parts. Toward the center it becomes slightly flattened or convex and thus forms a very rudimentary pseudodeltidium. It extends beneath the apex at an angle of about 45° to the plane of the margins of the valve. The central portion of the pseudo area extends about one-half the distance from the apex to the plane of the valve and forms a gentle arch.

A partially exfoliated shell shows four dark lines radiating forward from the umbo and two near the sides that may have something to do with the muscle scars or vascular sinuses. I thought so in 1886,[a] but am not sufficiently confident of it now to state it as a settled conclusion. Fine punctæ occur on the inner layer of the shell; also numerous radiating lines about one-half a millimeter apart.

Dorsal valve gently convex in young shells. With increase in size the umbo becomes more elevated and the apex points upward or terminates at the union of the pseudo area and the upward slope of the shell on the umbo. In some shells there is a tendency for the valve to become slightly concave in the space between the margins and the elevated umbo. The pseudo area of the valve is narrow and with little character; on some shells it slopes beneath the apex, and on others it slopes backward, forming a low angle with the surface of the valve. The interior of the dorsal valve shows a median septum, with two central scars, and the anterior lateral scars. Numerous small vascular canals radiate from central concave area toward the flattened anterior and lateral half of the valve. A cast of the interior shows two vascular canals radiating forward from near the apex. Radiating lines occur on the interior of the same character as those of the ventral valve.

Observations.—Since writing on this species in 1886 I have collected specimens showing the character of the pseudo areas of the valves, and also obtained further information relative to the interior of the dorsal valve. The rudimentary or pseudo areas are less advanced in development than those of *Iphidella*, and the muscle scars of the dorsal valve are much like those of *Obolella* and *Obolus*.

The specimens from Bic Harbor and east of Swanton, Vermont, are better than those from the type locality at L'Anse au Loup. Many of the Vermont shells are larger and more fully developed, but specimens of the same size as those from L'Anse au Loup and Bic Harbor are identical in the characters available for comparison.

Formation and locality.—Lower Cambrian. L'Anse au Loup limestone with *Olenellus thompsoni* at L'Anse au Loup, on the north shore of the straits of Belle Isle, Labrador. In bowlders of limestone containing fragments of Olenellus, in Cambrian conglomerate, at East Point, Bic Harbor, Province of Quebec, Canada. The species is abundant in lenticular masses of limestone intercalated in argillaceous and arenaceous shales carrying *Olenellus thompsoni* on the Bullard farm, about two miles east of Swanton, Vermont.

Dr. Eduard von Toll[b] identifies and illustrates as *Kutorgina cingulata* Billings a dorsal valve that occurs with other forms that may be referred to the Lower Cambrian fauna of the Cambrian of Siberia.

Locality.—Near the Tschurskaja Station, on the Lena.

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[a] Bull. U. S. Geol. Survey, No. 30, p. 103.

[b] Beitrage zu Kenntniss des Sibirischen Cambrium, I. Mém. de l'Acad. Imp. des Sci. de St. Pétersbourg, VIII sér., 1899, pp. 26–27.

KUTORGINA PERUGATA, new species.

General form ovate, biconvex. Surface marked by concentric lines of growth and more or less strong concentric corrugations; the outer surface is ornamented by a fine network of oblique, depressed lines, that leave minute rhomboidal elevations between them that look like fine papillæ under a moderately strong magnifier, and the cast of the surface has much the same appearance in a transverse light. Shell substance calcareous.

A large ventral valve has a length of 14 mm.; width, 16 mm. A dorsal valve 11 mm. in length has a width of 14 mm.

The ventral valve is strongly convex in adult shells, with the highest point near the umbo or at the apex. The apex terminates at or overhangs a rudimentary pseudo area that slopes beneath the shell at an angle of 45 to 60 to the plane of the margins of the valve. The pseudo area is concave and about half the length of the space between the apex and the plane of the valve. Casts of the interior show well-defined main vascular sinuses, with the outline of the visceral area between them.

The dorsal valve is transverse, nearly flat in some examples, and slightly convex in others. The surface slopes gradually from the margins to near the umbo, where the slope increases and extends to the upward-pointing apex. A rudimentary pseudo area slopes backward from the apex. In some examples the pseudo area appears to be little more than a bending over of the posterior margins of the shell; in others it has the outline of a slightly convex pseudodeltidium.

Observations.—This species, in its reticulate surface ornamentation, recalls *Iphidella pannula* and *Mickwitzia monilifera*. In form the young shells are not unlike *Kutorgina cingulata*. A large, imperfect ventral valve, 24 mm. by 24 mm., of this genus, was collected by Mr. J. E. Clayton from the Cambrian limestone of the Silver Peak district. It may belong to *K. perugata*, and it is so referred for the present. From the shales of the Olenellus zone in Silver Canyon, White Mountain range, a series of compressed specimens were collected. Some of these show a concave pseudo area on the ventral valve, also strong main vascular sinuses. Some of the shells from the shales north of Red Mountain have lost all traces of surface characters, only a faint, smooth impression remaining.

Formation and locality.—Lower Cambrian. Calcareous shales beneath Archæocyathus limestone, 3 miles north of Valcadi Spring or 4 miles northwest of Drinkwater Mine; summit on road 10 miles southwest of town of Silver Peak; also on divide between Clayton and Fish Creek valleys, north of Red Mountain, Silver Peak Range; Silver Peak District, Esmeralda County, Nevada. About 1,000 feet above quartzite, Silver Canyon, White Mountain Range, Nevada.

KUTORGINA SARDINIAENSIS, new species.

Kutorgina cingulata BORNEMANN, Nova Acta der Ksl. Leop-Carol. Deutsch. Acad. Naturf., LVI, 1891, No. 3, p. 440, pl. XIX, figs. 22, 23.

Lingula rouaulti BORNEMANN, Nova Acta der Ksl. Leop-Carol. Deutsch. Acad. Naturf., LVI, 1891, No. 3, p. 439, pl. XIX, fig. 21.

Transversely oval, more or less arched, with straight margin which is a little shorter than the greatest breadth of the shell. Surface shows strong concentric lines of growth.

Found quite commonly in the slates with *Olenopsis* and *Metadoxides* near Canalgrande, solitary also in sandstone with *Archæocyathus* on Punta Pintau. The specimens in slate are always pressed very flat, and are imperfect; in the sandstone are found impressions of the outer surface.

Here belongs perhaps also the shell designated above as *Lingula rouaulti* (?).

The specimens of this species are all more or less flattened in the argillaceous shale. It appears to be congeneric with *Kutorgina cingulata*, but not specifically identical with it.

Formation and locality.—Middle? Cambrian shales near Canalgrande, and in sandstone on Punta Pintau, Island of Sardinia.

KUTORGINA, species undetermined.

Ventral valve transverse, moderately convex; length 6 mm., width 8 mm.; pseudo area short and sloping beneath the apex at an angle of about 45°.

A single cast from a coarse sandstone is all that is known of this species. It may be a young shell of *K. cingulata*, but the means of comparison do not justify such a reference.

Formation and locality.—Lower Cambrian sandstone of Sollings Mountain, 2 miles east of Natural Bridge, Virginia.

RUSTELLA, new genus

All that is known of this genus is the type species, *Rustella edsoni*. It appears to be the most primitive form of brachiopod known.

The generic name is given in memory of William P. Rust, of Trenton Falls, New York, whose collections from the Lower Cambrian strata of Georgia, Vermont, were most extensive and the material the finest obtained there.

RUSTELLA EDSONI, new species.

General form, subcircular, biconvex. Ventral valve moderately convex, with the apex at the posterior margin immediately above a low arch in the posterior margin. Surface smooth except for concentric growth lines and low ridges that in some shells are quite prominent. A shallow, broad, rudimentary pedicle groove occurs beneath the apex and on a slightly flattened space adjoining the posterior margin. Dorsal valve about as convex as the ventral and with the apex marginal. The interior of the valve shows two rounded depressions beneath the umbo with a slight, narrow groove between them; a little in advance the outlines of the central muscle scars occur; originally strong but faintly indicated radiating lines occur toward the front.

Observations.—This shell was identified as the dorsal valve of *Kutorgina cingulata* by Mr. Billings[a] and myself.[b] They were considered as distorted, flattened shells. Better material shows them to represent one of the simplest forms of brachiopod known; with the exception of the rudimentary pedicle furrow and the area there is nothing more than the gaping valve, a form near to Dr. Charles E. Beecher's ideal *Paterina.*

The specific name is given in recognition of the excellent work Mr. George Edson, of St. Albans, Vermont, is doing in collecting the Lower Paleozoic fossils of his region.

Formation and locality.—Swanton shales, just above Parker's quarry, Georgia, associated with *Olenellus thompsoni.*, and also two miles east of Swanton, Vermont.

Genus DICELLOMUS Hall.

Dicellomus HALL, Twenty-third Ann. Rep. N. Y. State Cab. Nat. Hist., p. 246.

Dicellomus HALL and CLARKE, Pal. New York, VIII, 1892, Pt. 1, p. 72.

Dicellomus WALCOTT, Mon. U. S. Geol. Survey, XXXII, 1899, Pt. 2, p. 446.

Shell small; general form ovate to subsemicircular, biconvex, with apices marginal. Surface of outer shell finely punctate in all species where it is preserved uninjured. Interior or middle lamellæ marked by radiating striæ and minute punctæ; inner surface finely punctate. The shell is thick in all the species now known, and is built up of a thin, outer, scabrous layer, numerous inner layers or lamellæ, and a thin inner layer. Shell substance apparently calcareo-corneous.

The interior of the ventral valve shows a short area with a median pedicle groove; an elongate visceral area; well-marked main vascular sinuses; large, composite scars where the posterior muscles, i. e., transmedian and anterior laterals, were attached; and a short shelf or embryo spondylium that extended into the valve from each side of the pedicle groove. This plate corresponds to the dental plate in the articulate brachiopods, and it has a thickness at the antero-lateral margin that suggests a short tooth.

The interior of the dorsal valve has a well-defined but very narrow area in one species, *D. politus*, that is hollowed out so as to form a shallow groove on each side, apparently for the reception of the short tooth of the ventral valve. No good posterior margins of the valve could be found of the other species of the genus. The composite scar is large, and in one shell it is subdivided into three small scars that were the points of attachment of the transmedian, outside, and middle laterals. The central and anterior lateral scars are arranged as in *Obolus*; the centrals are large and located on the sides of the visceral area; the anterior laterals are small and located at the arterial end of the visceral cavity.

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[a] Pal. Fos., I, p. 9.

[b] Tenth Ann. Rept. U. S. Geol. Survey, p. 609, pl. LXIX, figs. 1, 1a–h.

Observations.—When referring to *Dicellomus*, in 1899, I said:[a]

> When proposing that the genus Dicellomus[b] include *Obolella polita*, Professor Hall stated that the grooving or emargination of the apices of both valves and the thickening of the edges of the shell on each side below the apex, together with the form and character of the muscular impressions, would separate the species from *Obolella*. Again in 1892 Messrs. Hall and Clarke[c] gave a fuller description of *Dicellomus politus*, but owing to the poor character of the material they did not feel confident that it should be recognized as generically distinct from *Obolella chromatica*. Material now in the collections of the Geological Survey clearly shows that Professor Hall's provisional conclusion was correct, and that *Dicellomus politus* is generically distinct from *Obolella chromatica*.

The presence of the large, composite, cardinal muscle scars in each valve suggests that a search be made for a foraminal opening, as in *Obolella*, *Linnarssonella*, and *Acrotreta*. No trace has been found externally, and the interior of the ventral valve does not show evidence of it. *Dicellomus* appears to include characteristics of *Obolus* and *Obolella*, and on the presence of the incipient dental plates, teeth, and dental grooves an articulate shell is suggested. In *Mickwitzia prima* a step further is taken in the development of the spondylium and in the approach toward articulating brachiopods.

The stratigraphic range of *Dicellomus* is from the Middle Cambrian to the latter part of the Upper Cambrian. Its geographic distribution includes the Appalachian area in Tennessee and Alabama, the Mississippi basin from Wisconsin and Minnesota on the north to Oklahoma on the south and South Dokota, Montana, and Utah on the west. The Arizona locality appears to be an extension to the southwest of the upper Mississippi Valley species, *D. politus*. The only form from Europe is suggested by the unidentified shell from the *Paradoxides forchhameri* zone of Anduarum, Sweden.

The species now referred to the genus are:

Dicellomus appalachia, Middle Cambrian.
D. parvus, Middle Cambrian.
D. pectenoides, Middle Cambrian.
D. politus, Middle Cambrian.
D. species undetermined, Middle Cambrian.
D. nanus, Upper Cambrian.

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[a] Mon. U. S. Geol. Survey, XXXII, Pt. 2, 1899, p. 446.

[b] Twenty-third Ann. Rept. New York State Cab. Nat. Hist., p. 246.

[c] Pal. New York, VIII, Pt. 1, p. 72.

DICELLOMUS APPALACHIA, new species.

This shell has been identified with *D. politus* in the preliminary studies of the genus Dicellomus. I find that while it has the same type of shell structure and general form, it differs in being less elongate proportionally, and in the details of the form and positions of the muscle scars and vascular markings of the interior of the valve; it differs in the latter respect from *D. nanus*. The outer thin layer has a dull, slightly roughened surface that is minutely punctate. When the outer layer is exfoliated the surface of the layer beneath is highly polished and marked by exceedingly fine radiating striæ and concentric striæ and lines of growth. The interior of the dorsal valve shows the larger central muscle scars with the minute antero-lateral scars almost in contact with them. A composite scar shows the separate points of attachment of the transmedian, outside, and middle lateral scars. The variation in the length of the visceral cavity of the dorsal valve is very great.

This species occurs in great abundance in both limestones and shales. It is the representative of the widely distributed *D. politus* of the interior of the continent.

Formation and locality.—Middle Cambrian. Limestones beneath the upper shale of the Cambrian section at many localities in Jefferson and Hawkins counties; limestone layers in Conasauga shale, 2 miles south of Coal Creek, Anderson County; in shale on road from Rogersville to Dodson Ford; limestone at Bull Run, Copper Ridge, 11 miles northwest of Knoxville, southwest of Maynardsville, and 5 miles southeast of Greenville, Tennessee.

Coosa shale, Cowan Creek and Cedar Bluff, Cherokee County, Murphees Valley, and Blountsville Valley, Alabama.

DICELLOMUS NANUS Meek and Hayden.

Obolella nana Meek and Hayden, Proc. Acad. Nat. Sci. Philadelphia, 2d ser., V, 1861, p. 435.—Billings, Pal. Foss., I, 1862, p. 67.—Hayden, Am. Jour. Sci., 2d ser., XXXIII, 1863, p. 73.—Meek and Hayden, Pal. Upper Missouri, Pt. 1, 1864, p. 4, pl. i, figs. 3*a*–*d*.—Whitfield, U. S. Geog. and Geol. Surv. Rocky Mountain Region, 1880, p. 340, pl. ii, figs. 14–17.—Hall and Clarke, Pal. New York, VIII, 1892, Pt. 1, p. 69.

Dicellomus nanus Walcott, Mon. U. S. Geol. Survey, XXXII, 1899, p. 447, pl. lx, figs 3, 3*a*–*d*.

The principal characters of this species are the same as *Dicellomus politus*. The two forms differ exteriorly in *D. nanus* being more convex on the umbones and less elongate. The interior of the ventral valve shows a less elongate visceral area, a relatively larger composite muscle scar. The interior of the dorsal valve of *D. nanus* has a much larger composite muscle scar, a broader visceral area with the central muscle scar farther from the median line.

One of the types of *D. nanus* is the interior of a ventral valve, on which there is a subtriangular depression that appears to have been the path of advance of the area, on each side of the median space, in which the central muscle, middle, and outside lateral muscles were attached. Another shell from the Big Horn Mountains shows something of the same character.

The area of the ventral valve is short, and divided midway by a shallow pedicle furrow; area of dorsal valve unknown.

The exterior of the shell appears to be smooth and slightly polished, except for fine concentric striæ and lines of growth and what appear to be scattered punctæ.

The average size of the adult shells is from 3 mm. to 4 mm., the length and width usually being nearly the same.

The exact horizon of the type specimens is unknown. They occur in a somewhat friable, purplish sandstone, unlike any beds of the Middle Cambrian Deadwood sandstone that I met with. The specimens from the limestones of the Big Horn Mountains, etc., appear to belong to the Uppper Cambrian terrane.

Formation and locality.—Upper Cambrian. Shaly sandstone, Black Hills, North Dakota. Limestone above shales, about 10 miles south-southeast of Bald Mountain, Big Horn Mountains; Gallatin limestone, Crowfoot section, Gallatin Range, Yellowstone National Park, Wyoming. Limestone of the Little Rocky Mountains, west side of Dry Creek, below Pass Creek, Gallatin Valley.

Two specimens of a shell apparently identical with *D. nanus* were broken from a diamond drill core, taken from a fine sandstone 20 feet above the La Motte sandstone, St. Francois County, Missouri.

DICELLOMUS PARVUS, new species.

General form ovate, with the ventral valve subacuminate and dorsal valve broad oval to subcircular. Valves moderately convex. Surface of outer shell dark and polished; it is marked, when not abraded, by fine, clearly defined, concentric striæ and occasional lines of growth. The largest ventral valve has a length of 2.5 mm. and a width of 2 mm. The shell is strong but not thick. Shell substance apparently calcareo-corneous.

Ventral valve uniformly convex, except that the slopes toward the cardinal margins are more abrupt than elsewhere; apex appears to be marginal. The interior of the valve shows a short, low, median ridge in the center of the visceral cavity; on each side, and a little in front of the end of the median ridge are the trapezoidal areas for the attachment of muscle scars; rather small, composite cardinal muscle scars occur close to the cardinal margins.

Dorsal valve somewhat less convex than the ventral; apex marginal. The interior of the valve shows well defined composite cardinal muscle scars, a narrow median septum, and faintly impressed main vascular sinus that curves outward and forward at about one-third the distance from the outer margin to the median septum; the central muscle scars are small and situated back of the center of the valve on each side of a low median swelling on which the median septum occurs; the position of the anterior lateral muscle scars is indicated at the end of the median septum a little in advance of the center of the valve.

Observations.—This minute shell has the generic characters of *Dicellomus politus*, but it differs specifically in minute size and the positions of the muscle scars in the dorsal valve.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Two and one-half miles southwest of Yen Chuang, Shantung, China.

Also from a river drift block one mile south of Chen Ping Hsien, on the Lan Ho River, southern Shensi.

Collections of Bailey Willis and Eliot T. Blackwelder, Carnegie Institution Expedition to China.

DICELLOMUS PECTENOIDES Whitfield.

Obolus pectenoides WHITFIELD, Ludlow's Rept. Reconnaissance Black Hills of Dakota, 1875, p. 103, figs. 1, 3.

Obolus? pectenoides WHITFIELD, Geol. and Geog. Surv. Rocky Mountain region, Powell, 1880, p. 328, pl. II, figs. 18, 19.

Obolella pectenoides SCHUCHERT, Bull. U. S. Geol. Survey, No. 87, 1897, p. 275.

This is the largest shell of the several species of the genus. A ventral valve 9 mm. long has a width of 11 mm. All that is known of the structure of the shell indicates that it was like *D. politus.* This species differs from all the other species by the anterior position of the central muscle scars of the dorsal valve, and its larger size.

Formation and locality.—Middle Cambrian. Deadwood sandstone, Castle County, on west side of the Black Hills; also at Deadwood, in the cliffs on the east side of the valley, South Dakota.

DICELLOMUS POLITUS Hall.

Obolus appolinus OWEN (not Eichwald), Geol. Surv. Wisconsin, Iowa, and Minnesota, 1852, pl. I B, figs. 9, 11, 15, 20.

Lingula? polita HALL, Ann. Rept. Geol. Surv. Wisconsin, 1861, p. 24; Geol. Rept, Wisconsin, I, 1862, pp. 21, 435.

Obolella? polita HALL, Sixteenth Ann. Rept. New York State Cab. Nat. Hist., 1863, p. 133, pl. VI, figs. 17–21; Trans. Albany Institute, V, 1867, p. 112.

Lingulepis prima MEEK and HAYDEN, Smithsonian Contrb. to Knowl., XIV, 1864, No. 172, p. 3, pl. I, fig. 2.

Dicellomus polita HALL, Twenty-third Ann. Rept. New York State Cab. Nat. Hist., 1873, p. 246.

Obolella polita WHITFIELD, Geol. and Geog. Surv. Rocky Mountain Region, 1880, p. 339, pl. II, figs. 12, 13.

Obolella polita WALCOTT, Bull. U. S. Geol. Survey No. 30, 1886, p. 111.

Obolella polita HALL and CLARKE, Pal. New York, VIII, 1893, Pt. 1, pp. 72, 73, pl. II, figs. 37–41.

Dicellomus politus WALCOTT, Mon. U. S. Geol. Survey, XXXII, 1899, Pt. 2, p. 446, pl. LX, figs. 4, 4*a*.

General form ovate, with the ventral valve subacuminate; biconvex, the ventral valve usuallly more convex than the dorsal. Surface smooth as the specimens usually occur, but a few examples show that there is a thin outer layer covered with fine papillæ and punctæ that appear to be placed on very fine, more or less inosculating ridges. Concentric lines of growth of varying strength show on the outer surface, also on the various inner layers or lamellæ. When the outer layer is exfoliated or worn off by attrition of the sand, the surface of the inner layer is marked by radiating striæ and concentric lines of growth that are a marked feature of the species. The radiating striæ may be uniform in size, or with from 4 to 6 very fine striæ between two stronger elevated striæ. Inner surface smooth to the eye, but a strong lens shows that it is finely punctate, with exceedingly fine, irregular, raised lines all over the surface. The intermediate layer is more coarsely and irregularly punctate.

The shell is thick and is built up of a thin, scabrous, outer layer, a middle layer made up of several highly polished lamellæ, and a thin inner layer. The numerous inner lamellæ are oblique to the outer surface over much of the shell, and thus give it thickness. Shell substance calcareo-corneous. The usual size of the Wisconsin shells is about 6 mm. long, width 5 mm., for ventral valve, and same width and length for dorsal valve. Specimens from the Black Hills average a trifle larger than those from Wisconsin.

Ventral valve with a uniform convexity over the central portions, from which the surface slopes gently to the margins. Apex nearly, if not quite, marginal. Casts of the interior indicate a short cardinal area that extends out on the cardinal margins of the shell, and that appears to merge into the margins. On each side of the pedicle furrow a thin plate or shelf extended into the valve on the plane of the margins of the shell. Some of the casts indicate that these plates had a projecting boss or tooth that articulated in a rude manner with the depressions on the posterior, flattened, inner margin of the dorsal valve. If this interpretation is correct, the teeth and plates correspond to the teeth and dental plates of the articulate brachiopods, and the plates mark the beginning of a spondylium. The posterior muscles, transmedian and anterior laterals were undoubtedly attached within the area of the composite scar. The visceral area and posterior portions of the main vascular sinuses are well outlined, but no muscle scars or details of the vascular system have been preserved in the material studied.

Dorsal valve most convex back of the center. Apex marginal. The interior of the valve shows shallow depressions in the flattened posterior margin that suggest dental cavities for the reception of the dental projections of the ventral valve. The composite muscle scar probably formed the point of attachment of the posterior muscles, transmedian, outside, and middle laterals. The central muscle scars are shown a little back of the center of the valve, where a low median ridge bifurcates. In some shells a sharp median septum is shown; also narrow main vascular sinuses.

Observations.—The specimens of this shell from Wisconsin, Minnesota, and North Dakota occur in fine-grained, more or less friable sandstone; those from Montana in a compact limestone in the Gallatin Valley and a siliceous shale at Helena. The reference of the specimens from Helena is rather doubtful, as the shells are compressed and distorted.

The beds in which the specimens are found at Taylors Falls, Minnesota, are said to be Upper Cambrian. If this is correct *D. politus* ranges from the Middie to the Upper Cambrian. Shells agreeing with *D. politus* in all points available for comparison occur in the basal, probably Middle Cambrian, sandstone beneath the great limestone series of Arizona. The material is abundant and preserved very much in the same condition as that from the Deadwood sandstone of the Black Hills of South Dakota.

In the sandstones at the base of the Middle Cambrian Reagan formation a few shells were found that appear to be identical with *D. politus.* They have the elongate form of that species, which is unknown in any other species of the genus.

In the collections made by the fortieth parallel survey there are specimens so closely resembling *D. politus* that they are identified as such, although the dorsal valve is rather transverse.

Dicellomus politus differs from *D. nanus* and *D. pectenoides* in being more elongate; also in the details of the interior markings of the valves. From *D. appalachia* it differs in interior markings and, as specimens average, in being more elongate.

Formation and locality.—Middle Cambrian. St. Croix sandstone, middle beds of the sandstone, at Eau Claire, Wisconsin. Deadwood sandstone, 9 miles west of Custer City; head of Red Water Canyon and several other localities in the Deadwood standstone of the Black Hills, South Dakota. Gallatin limestone, near Gallatin, and also in Silurian shales with *Obolus* (*Lingulella*) *helena* and *O.* (*Westoria*) *ella*, on the southern slope of Mount Helena at Helena, Montana. Basal sandstone. Ash Creek, Pinal County, Arizona. Basal sandstone of the Reagan formation, Wichita Mountains, 11 miles northwest of Fort Sill in the SW. ¼ sec. 17, T. 4 N., R. 12 W., Oklahoma Territory.

Upper (?) Cambrian. Upper beds of St. Croix sandstone at Taylors Falls, Minnesota.

DICELLOMUS, species undetermined.

A single specimen of a ventral valve very much like that of *Dicellomus appalachia* occurs with material from the *Paradoxides forchhameri* zone at Andrarum. A series of specimens would probably prove that it is the representative of an undescribed species.

Formation and locality.—Middle Cambrian. Andrarum, Sweden.

CURTICIA, new genus.

The description of the type species, *Curticia elegantula*, includes all that is known of this genus.

The generic name is given in recognition of the excellent work of Dr. Cooper Curtice, of Moravia, New York, both as a field collector and laboratory assistant for several years.

CURTICIA ELEGANTULA, new species.

General form, subcircular, biconvex. Surface of exterior of shell marked by fine concentric, slightly undulating striæ, and lines and varices of growth. When the thin, exterior layer is exfoliated, the inner layers are ornamented by numerous fine, radiating lines, very much as in Dicellomus and Obolus, also more or less imbricating concentric lines. The inner surface shows radiating and concentric lines without the visceral area. Shell substance corneous and probably calcareous. The shell is built up of a thin, outer surface layer and several inner layers or lamellæ, slightly oblique to the outer surface on the umbo and central parts of the valves. The lamellæ are more oblique and numerous toward the front and sides, and thus thicken the shell over those parts. The average ventral valve has a length of 5 mm., width 6 mm.; dorsal valve, 5 mm. by 5 mm.

Ventral valve strongly convex, most elevated at the umbo, and arching over to a minute, slightly incurved apex; area rudimentary, with a high, triangular, open delthyrium occupying most of it. A cast of the interior of the valve shows that a narrow elevated ridge occurs just in advance of the apex.

Dorsal valve evenly convex, apex marginal. The interior shows a median ridge and septum, with small rounded depressions beneath the umbo on each side of the median ridge and a little in advance of the apex. Ventral muscle scars small and clearly defined. Anterior lateral scars small, and situated in advance of the central scars close to the median ridge and at its anterior extremity. Main vascular sinuses broad and slightly defined.

Observations.—This shell was labeled *Dicellomus politus*. In external form it resembles it, but the open delthyrium of the ventral valve and the absence of area on dorsal valve distinguish it. It appears to be a form intermediate in development between *Rustella* and *Dicel-*

lomus. It occurs in large numbers and is a very striking object, with its dark, smooth shell in the buff-gray sandstone.

Formation and locality. Upper Cambrian. St. Croix sandstone, Taylors Falls, Minnesota.

QUEBECIA, new genus.

The description of the species includes that of the genus as there is only one species now known.

Type.—*Obolella circe* Billings.

QUEBECIA CIRCE Billings.

Obolella circe BILLINGS, Canadian Nat., n. ser., VI, 1872, p. 219; Am. Jour. Sci., 3d ser., III, 1872, p. 357.—WALCOTT, Bull. U. S. Geol. Survey No. 30, 1886, p. 118, pl. x, fig. 3a; Tenth Ann. Rept. U. S. Geol. Survey, 1891, p. 611, pl. LXXI, fig. 3a.

General form broad ovate, with front and sides uniformly rounded; planoconvex. Surface marked by fine concentric striæ of growth. A ventral valve 3.5 mm. in length has a width of 4.5 mm. A dorsal valve 4.5 mm. in length has the same width; a larger dorsal valve, 11 mm. in length, has a width of 10.5 mm. Shell rather thick, and composed of calcite in its present condition.

The ventral valve has an elevated umbo terminating in a sharp, upward pointing apex that may be perforate; from the umbo the surface, in young shells, slopes so rapidly that the central and outer portions of the shell are nearly flat, but in older shells moderately convex; area short and divided midway by a relatively broad delthyrium that is nearly covered by a convex deltidium; the inner surface is marked by fine, elevated, rather widely separated, radiating striæ and very fine punctæ; a pair of very broad main vascular sinuses arch forward from a point beneath the umbo and inclose a small, slightly elevated visceral area; a strong cardinal tubercle occurs on each side of the pseudo area, which was probably the point of attachment of the posterior muscle, i. e., transmedian and anterior laterals.

Dorsal valve gently convex in young shells, becoming strongly convex in old shells; no traces of an area have been observed—if present it must have been short and very low, as the beak is nearly at the plane of the margins of the shell; casts of the interior show that the valve was thickened beneath the umbo by a ridge that separated what may be called the umbonal cavity from the main cavity of the valve. On the cast of an old shell a rounded, narrow, longitudinal, median ridge divides the umbonal cavity; on each side of the cavity and beyond it there is the strongly marked path of advance of the transmedian muscle scars; in front of the transverse ridge two strong ridges that extend toward the center of the valve occupy the position of the main vascular trunks; in one specimen a narrow groove extends from the central muscle scar along the inside margin of the ridge.

The muscle scars now known are the transmedian and central; the former are situated close to the margin of the valve, and the space assigned them may also include the posterior laterals; the central scars are well indicated in several specimens, but no trace has been found of the antero-laterals. The cardinal tubercle includes the space that was occupied by the several points of attachment of the posterior muscles, i. e., transmedian, outside, and middle laterals; the cast of the tubercle is an elongate depression just inside the margin of the shell.

Observations.—By incorrect interpretation both Mr. Billings and myself identified the dorsal valve of the species as the ventral, and I followed him in illustrating a dorsal valve of *Obolella crassa* as the dorsal valve of *O. circe*. When studying some material representing the species in the collections of the United States National Museum I noticed the edge of a shell that, on working it free from the matrix, proved to be a ventral valve; two dorsal valves occur on the same bit of rock. Subsequently Dr. J. F. Whiteaves sent me a tablet from the collections of the Geological Survey of Canada, on which six specimens were labeled *Obolella circe*. No. 1 is a cast of the interior of the dorsal valve of *Obolella crassa*, and No. 2 the exterior of same. Nos. 3 and 6 are ventral valves of *Quebecia circe*, and Nos. 4 and 5 dorsal valves.

With the ventral valve identified, it appears that the shell is not an *Obolella* but is the type of an undescribed genus, in which the ventral valve is elevated at the apex, and with strong cardinal tubercles for the attachment of the posterior muscle scars, very much as in Acrotreta. This feature, and the presence of what appears to be the base of the cast of a foraminal tube, suggest that the ventral valve was perforate. *Quebecia* appears to be on the line of evolution from *Obolella* to the calcareous, perforate, inarticulate shells represented by *Yorkia*. *Obolella*, *Quebecia*, and *Yorkia* are all strong, calcareous, perforate shells of the older Cambrian fauna, and are evidently closely related.

Formation and locality.—Lower Cambrian. Limestone bowlders in conglomerate at Trois Pistoles, on the St. Lawrence River, below Quebec, Canada.

Genus ELKANIA Ford.

Billingsia FORD (not de Koninck, 1876), Amer. Jour. Sci., 3d ser., XXXI, 1886, p. 466.

Elkania FORD, Amer. Jour. Sci., 3d ser., XXXII, 1886, p. 325.

Elkania HALL and CLARKE, Pal. New York, VIII, 1892, Pt. 1, pp. 75, 165; Eleventh Ann. Rep. New York State Geologist, 1894, p. 241.

General form ovate, biconvex; shell substance corneous and made up of several thin layers or lamellæ that increase in number toward the front and lateral margins. Surface marked by fine concentric striæ of growth. Apex of both ventral and dorsal valves marginal. The interior of the ventral valve has a thickened posterior section which has a central pedicle furrow, and two flexure lines running obliquely forward and outward from the apex, a little inside of the grooves of the main vascular trunks; this structure is apparently the result of the union of the area with the bottom of the shell, so as to bring, as the shell grew, the path of advance of the pedicle groove, main vascular sinuses, and lateral muscle scars all on one surface instead of on the area and the shell beneath it, as in *Obolus*.

The muscle scars are arranged as in *Obolus*. The transmedian and anterior laterals occur well out toward the margin, and the space inclosing the central scars, middle and outside laterals, is in the central area, on the front of the slope of the thickened posterior portion of the valve; the points of attachment of the individual muscles can not be distinguished. In the dorsal valve the central and anterior lateral scars are clearly shown in several specimens. The transmedian and outside laterals are situated just outside the main vascular sinus. Our knowledge of the vascular markings is limited to the main vascular sinuses, except in one ventral valve where the inner branches have been preserved. In both valves the main trunk rises near the apex and its path is outlined across the reversed area.

The preceding description differs materially from that of Messrs. Ford and Hall and Clarke. I find the muscle scars as described above, and am compelled to consider them as indicating the same muscles as in *Obolus*. That the genus is an advance on *Obolus* in the evolution of the inarticulate brachiopods, I quite agree with Hall and Clarke; also that it is a stage in the transition from *Obolus* to *Trimerella* and its allies. The stage, however, is not far along, as nothing is seen of the platform in advance of the area, and the area is merged into the body of the shell. *Elkania* is an *Obolus* with the cardinal areas within the plane of the margins of the valves. In the type species, *E. desiderata*, the area of the ventral valve is entirely within the valve, while that of the dorsal valve has been nearly obliterated in the process of change from an open backward-facing area to an inclosed forward-facing area. A comparison of the interiors of *Obolus* (*L.*) *cœlatus* and *Obolus apollinis* with those of *Elkania desiderata* and *Elkania bellula* illustrates that little change is necessary to convert the exterior cardinal areas of *Obolus* into the inclosed reversed areas of *Elkania*.

As the beaks of *Elkania* are marginal, the pedicle passed out though an opening made by the gaping of the valves.

The four known species of the genus are the type species, *Elkania desiderata*, *E. ida*, *E. ambigua*, in which the shell is very thick, and *E. bellula*, a minute shell in which the form and tendency is towards *Lingulella* rather than the thick oval forms of *Obolus*.

Lingulasma Ulrich, has an inclosed cardinal area, and is a more advanced stage than *Elkania* in the transition from *Obolus* and its subgenera to the true Trimerelloid forms.[a]

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[a] See Pal. New York, VIII, Pt. 1, pp. 24-28, 30-33.

Authors have referred frequently to the resemblances between species of *Obolella* and *Elkania desiderata.* These do not appear to exist except in a superficial manner. *Obolella* is a stage in the evolution toward the Siphono-tretidæ, while *Elkania* is toward the Trimerellidæ.

ELKANIA BELLULA, new species.

General form elongate oval; biconvex; beaks marginal. Surface marked by fine concentric striæ of growth that occasionally form varacies and small ridges near the umbo; the inner layers or lamallæ have radiating striæ in addition to concentric striæ.

The shell is relatively thin and small. It rarely exceeds 2.5 mm. in length and a little less in width; the dorsal valve is a somewhat shorter than the ventral.

Ventral valve subacuminate, moderately convex; the interior shows a reversed cardinal area attached to the bottom of the valve and below the plane of the margins of the valve; the pedicle groove is strong; the line of demarcation between the cardinal area and the bottom of the valve is indefinite, as the margin of the area and the body of the shell have been merged into each other; the transmedian and antero-lateral muscle scars are outside the main vascular sinuses and near the margin of the valve; the central scars and middle and outside lateral scars are supposed to have been attached within an area which is largely on the front slope of the thickening of the umbonal portion of the valve.

The dorsal valve has a short reversed area; the antero-lateral muscle scars were probably well advanced toward the front, judging from traces of the length of the visceral cavity.

The vascular markings include the main vascular sinuses in the ventral valve and traces of the visceral area in the dorsal valve.

This pretty little shell is much like a small species of *Lingulella* in its exterior appearance; the interior connects it with *Elkania.* I know of no species closely related to it.

Formation and locality.—Upper Cambrian. Limestone about 3 miles south of Benders Pass, Silver Peak Range, Nevada.

SCHUCHERTINA, new genus.

The description of the type species is that of the genus and species, as but one species is known of the genus.

Type.—Schuchertina cambria.

The generic name is given in recognition of the admirable work that Prof. Charles Schuchert has done on the fossil brachiopods.

SCHUCHERTINA CAMBRIA, new species.

Shell subovate, with valves obtusely acuminate; biconvex. Surface marked by concentric lines and striæ of growth and fine radiating striæ. The inner and outer surfaces of the shells have very fine punctæ, but no traces of punctæ penetrating through the shell have been observed.

The largest ventral valve has a length of 22 mm., width 23 mm.; dorsal valve, length 17 mm., width 18 mm. Shell substance calcareous, rather thick on the umbonal region and thin towards the margins.

Ventral valve subacuminate, moderately convex; on some of the larger shells a broad mesial fold and arching of the frontal margin are present; apex terminates at the margin above a triangular opening or delthyrium; area small and within the plane of the margins of the valve; it is attached to the bottom of the valve and divided midway by a very slight pedicle groove; the margins of the delthyrium-like opening sustain an angle of about 45° to the plane of the valve, and the reversed area within is at its center nearly on the plane of the valve; the anterior margins of the area extend upward to meet the margins of the shell, thus forming a reversed arched area. The interior of the valve is marked by radiating, shallow, narrow furrows that vary in number and strength in different shells; just in front of the area on each side of the median line oval depressions occur which correspond in position and shape to the diductor muscle scars of the ventral valve of the Orthidæ, and they are so interpreted. Traces of the adductor scars are found on each side of the median line. Dorsal valve obtusely acuminate, about as convex as the ventral valve; apex marginal on the broad, low, median arch of the posterior margin; no traces of an area have been observed. A broad, shallow mesial sinus and projecting front margin occur on adult shells. The position of the anterior and posterior adductor muscle scars is indicated, also the umbonal thickening in which the diductor muscles were probably attached, as there is no trace of a cardinal process. Radiating furrows like those in the ventral valve are strongly marked in adult shells.

Observations.—*Schuchertina cambria* is a shell that, as far as I know, is unique. In its exterior form it suggests a biconvex Orthoid genus, and this likeness is further increased by the flabelliform scars of the ventral valve; the smooth surface and reversed areas suggest *Elkania*, while the interior umbonal portion of the ventral valve points to *Quebecia*. It may be said that *Schuchertina* is a type derived from some early Cambrian form allied to *Quebecia* and that its general aspects affiliate it with the Orthidæ.

Formation and locality.—Middle Cambrian limestone. Thirteen miles south of Neihart, 1 mile below divide on road to Woolsey post-office, Montana.

OBOLUS ACADICA, new species.

Only interiors of the dorsal valve of this species occur in the collections made by Mr. S. W. Loper on McNeils Brook in 1900. The material was provisionally referred to *O.* (*L*) *concinnus*, but the broadly rounded subquadrilateral form of the dorsal valve seems to distinguish it from that species and also from *Obolus* (*Paleobolus*) *bretonensis*.

The visceral area is narrow, extending a little in advance of the center of the valve. The main vascular trunks are narrow and widely separated. They belong to the submarginal group and are thus quite unlike those of *O.* (*P.*) *bretonensis*. The exterior surface and ventral valve are unknown.

Formation and locality.—Upper Cambrian. Etage 3 of Matthew, McNeils Brook, 1½ miles east of Marion Bridge, Cape Breton, Nova Scotia.

OBOLUS ISMENE, new species.

This species is characterized by its elevated umbo, flattened posteriolateral margins, and relatively thin shell.

All that is known of the exterior surface indicates that it was nearly smooth, marked only by fine concentric striæ of growth. The inner layers of the shell are beautifully marked by fine concentric and radiating striæ that give the surface a cancellated appearance. The shell is built up of several layers or lamellæ that become more oblique to the outer surface toward the front.

Formation and locality.—Middle Cambrian. Potosi limestone, Flat River, Missouri.

OBOLUS MATINALIS Hall?

Lingulepis matinalis Hall, Sixteenth Annual Report N. Y. State Cab. Nat. Hist., 1863, p. 130, pl. vi, figs. 12, 13.

A form indistinguishable from this species occurs in a gray limestone of Upper Cambrian age. Only the general form of partially exfoliated shells is known.

Formation and locality.—Upper Cambrian. Chao Mi Tien limestone. Two-thirds of a mile west of Tai An Fu, Shantung, China.

Collection of Eliot T. Blackwelder, Carnegie Institution Expedition to China.

OBOLUS MINIMUS, new species.

This is a small shell of the general form of *Obolus shensiensis*. The ventral valve is obtusely accuminate and the dorsal nearly circular; valves gently convex. Surface marked by rather strong concentric lines of growth and numerous very fine concentric striæ. The inner layers of shell are shiny black and ornamented with numerous fine. radiating striæ and concentric lines. Shell built up of several thin layers or lamellæ that form a thin shell over the umbonal region that gradually thickens as the short, oblique lamellæ become more numerous toward the front and side margins. The three specimens in the collection average 3 mm. in transverse diameter; the ventral is a little longer than the dorsal valve.

A partially exfoliated ventral valve shows a well-marked visceral area, extending forward about one-third of the length of the shell; also narrow main vascular sinuses starting near the apex and extending obliquely forward well into the valve, about midway between the median line of the valve and the lateral margins. This neat little shell is distinguished by its nearly circular outline, low convexity, and small size.

Formation and locality.—Middle Cambrian. Chang Hsia limestone, Yen Chuang, Shantung, China.

Collection of Eliot T. Blackwelder, Carnegie Institution Expedition to China.

OBOLUS NUNDINA, new species.

This little shell differs from *O. anceps*, to which it appears to be most nearly related, by its more nearly circular dorsal valve, and its strongly concentrically-ridged surface. Its surface is formed by elevated, rounded, concentric ridges that are somewhat irregular. Very fine concentric striæ occur both on the ridges and on the interspaces between.

Formation and locality.—Middle Cambrian. Cold Creek, Llano County, Texas.

OBOLUS OBSCURUS, new species.

This species is represented by one interior of a small dorsal valve which is very distinctive, the exterior of a crushed dorsal valve, and numerous fragments of the shell scattered through the hard, dark gray, shaly sandstone. The large dorsal valve has a length of 9 mm., width 7 mm. The shell is strong and marked on its inner layers by radiating and concentric striæ; the outer surface has numerous fine, elevated, slightly irregular concentric striæ that, with a strong lens, give it a roughened appearance.

An interior of a dorsal valve shows a well-developed area, the greater portion of which is taken by the broad pedicle groove; a deep umbonal cavity with a narrow median septum and obscure main vascular sinuses on the outer margins of the cavity. Outside the sinuses on the postero-lateral slope, relatively large muscle scars are indicated.

With the data available no satisfactory comparisons can be made with other species. *O. obscurus* is a large strong shell of the general type of *Obolus rhea* of the Middle Cambrian of Wisconsin.

Formation and locality.—Middle Cambrian. Ku San shale. Three and one-half miles southwest of Yen Chuang, Shantung, China.

Collection of Eliot T. Blackwelder, Carnegie Institution Expedition.

OBOLUS SHENSIENSIS, new species.

General form ovate, with the ventral valve broadly subacuminate and dorsal valve obtusely rounded. Valves moderately convex in the specimens embedded in a fine-grained, dark limestone. Surface marked by fine, sharp, concentric striæ and traces of irregular, obscurely defined, low, radiating ridges; the interior layers show fine radiating striæ and concentric lines. The shell is strong and built up of numerous lamellæ oblique to the outer surface. The largest ventral valve has a length of 9 mm., width 7 mm. Nothing is known of the interior of the valves. The form, surface markings, and shell structure are much like those of *Obolus matinalis* and *O. tetonensis*. In outline *O. shensiensis* is more elongate than *O. matinalis* and less so than *O. tetonensis*.

Formation and locality.—Upper Cambrian. Chao Mi Tien limestone. Eight miles south of Ting Hsiang Hsien, and one mile south of Chen Ping Hsien, Shensi, China.

Collections of Bailey Willis and Eliot T. Blackwelder, Carnegie Institution Expedition to China.

OBOLUS TETONENSIS, new species.

The general form, convexity, and appearance of this species is so much like that of *Obolus matinalis* that a general description is unnecessary. It varies from that species in the shorter, more transverse dorsal valve, and the narrower outline of the ventral valve toward the beak.

This species occurs in great abundance in the thin-bedded limestone in the upper portion of the Cambrian section of the Teton Range, Wyoming, in association with *Billingsella pepina* and *Obolus* (*Lingulepsis*) *acuminatus* var. *meeki*. What appears to be the same species occurs nearly 700 feet lower in the section in a thin-bedded sandstone. The dorsal valve from this horizon is broader and more transverse posteriorly than the dorsal valve from the upper horizon.

Formation and locality.—Middle Cambrian, on the divide at the head of Sheep Creek, near north end of the Teton Range, Wyoming. Thin-bedded limestones, Belt Park, 6 miles out from Neihart, Montana. Three miles southeast of Malad City, Idaho, a smaller form, collected by Dr. A. C. Peale in Bostwick Canyon, Bridger Range, Montana, may belong to this species. It occurs in a fine-grained sandstone low down in the Paleozoic section.

Dark gray limestone, Ophir City, Utah.

OBOLUS TETONENSIS NINUS, new variety.

This variety differs from the parent species and from *O. matinalis* by the more elongate form of the dorsal valve and the more acuminate form of the ventral valve, the cardinal slopes of the latter extending much further forward in the variety *ninus* than in the two species.

The advanced position of the visceral area in the ventral valve may be compared with the visceral area of *Obolus* (*L.*) *crassus*.

Formation and locality.—Middle Cambrian. Reagan formation, one-half mile east of Canyon Creek, 15 miles northwest of Fort Sill, Oklahoma Territory; also on west side of Honey Creek, near SE. corner, sec. 35, T. 1 S., R. 1 E. NE. ¼ sec. 2, T. 2 S., R. 1 E. Ardmore map, Geological Survey, Indian Territory.

OBOLUS PHERES, new species.

This is one of the smallest of the *Obolus* species known to me. It recalls at first sight *O.* (*L.*) *winona convexus;* but it differs in having a thick, lamellated shell, and in being more rounded on the cardinal angles. The exterior surface is marked by concentric lines of growth. The shell is built up of thin layers or lamellæ, those toward the front and sides being arranged obliquely to the surface, as in all of the thick-shelled species of *Obolus*.

Formation and locality.—Upper Cambrian. Argillaceous shales, interbedded in sandstone at Fox Glen, 8 miles east of Baraboo, Wisconsin.

OBOLUS (LINGULELLA) CHINENSIS, new species.

General form broadly subovate with the ventral valve broadly subacuminate and the dorsal valve oval with the postero-lateral slopes somewhat straightened. There is some variation in the proportions of width and length in different shells. Valves rather strongly convex for so thin a shell, in this respect resembling species of *Dicellomus*. Surface marked by fine concentric striæ and lines of growth and very fine undulating concentric lines; this outer surface is usually a dull black and adheres to the matrix; when the outer layer is exfoliated the surface is shiny black and marked by numerous radiating striæ in addition to concentric striæ; the inner surface shows a few scattered punctæ in addition to radiating and concentric striæ outside the visceral area. The shell is of medium thickness and formed of a thin outer layer and several inner layers or lamellæ that are slightly oblique to the outer layer; the lamellæ are more numerous and more oblique to the outer layer over the anterior and antero-lateral portions of the shell. The ventral valves average 3 mm. in length, with width varying from 2 mm. to 2.5 mm. The dorsal valve is slightly shorter than the ventral when the two valves have the same width.

The interior of the ventral valve shows that the area is short and divided midway by a narrow pedicle furrow that merges into the visceral area, which extends forward about one-third the length of the valve; on each side of the anterior central portion of the visceral area there are two small trapezoidal areas within which the central scars and the middle and outside lateral muscle scars were attached; the small transmedian and antero-lateral muscle scars are situated close to the main vascular sinus opposite the anterior portion of the central visceral area. A partial cast of the interior of the dorsal valve shows a rather wide visceral area with the antero-lateral scars about the center of the valve and the central scars about one-fourth of the distance back from the center to the posterior margin. Of the impressions left by the vascular system only the main vascular sinuses of the ventral valve have been seen; these are situated about midway between the central visceral area and the margins of the valve.

Observations.—This species occurs abundantly in association with *Acrotreta shantungensis.* It is closely related in form to *O.* (*Lingulella*) *prindeli* of the upper Olenellus zone of eastern New York, and belongs with a group of small shells that have a wide vertical and geographical range, as is noted under the description of *O. L. prindeli.* With the data available for comparison it differs from *O. L. prindeli* in its shorter cardinal area and visceral area in the dorsal valve. From *O.* (*Lingulella*) *damesi* it differs in being broader in proportion to its length.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Two and one-half miles south of Yen Chuang, on NNE. spur of Hu Lu Shan, China.

Collected by Mr. Eliot T. Blackwelder, of the Carnegie Institution Expedition to China.

OBOLUS (LINGULELLA) DAMESI, new species.

The general descriptions of *O. L. chinensis* and *O. L. primus* apply so closely to this species that it does not appear necessary to do more than call attention to the points in which they differ. From *O. L. chinensis* this species varies in having a more elongate, acuminate ventral valve and ovate dorsal valve; the valves are also less convex. From *O. L. primus* it differs in the more gradual curvature of the sides from the apex to the front margin, in this respect resembling some varieties of *O. L. ferrugineous.* The average size of the ventral valve is about 5 mm. in length by 3.5 mm. in width.

The species is named after Dr. Wilhelm Dames, who first described the Cambrian faunas of China.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. About 3 miles southwest of Yen Chuang, Shan Tung, China.

Collected by Mr. Eliot T. Blackwelder, of the Carnegie Institution Expedition to China.

OBOLUS (LINGULELLA) ISSE, new species.

In form and size this shell recalls *O.* (*L.*) *pogonipensis;* it differs from it in the form of the dorsal valve and the character of the outer surface. The shell is rather strong and made up of several thin layers or lamellæ. Its outer surface is marked by concentric lines of growth, sometimes grouped in more or less elevated bands, and over all there is a thin encrusting or scabrous layer that has a minutely granular, dull surface, somewhat like that of *O.* (*Lingulepis*) *gregwa* but very much finer in its granulations or points. The inner layers of the shell are dark, shiny, and marked by concentric lines of growth and radiating striæ.

Formation and locality. Middle Cambrian. Near Cave Spring, Fish Creek Range, Utah.

OBOLUS (LINGULELLA) ORUS, new species.

This is a shell of the *O.* (*L.*) *manticulus* form, but differs from it in being more elongate; ventral valve more acuminate and dorsal valve proportionally larger. Its nearest allies in form are among the group of narrow, elongate shells occurring across the continent at Cape Breton. It differs from all of them *O.* (*L.*) *collicia*, *O.* (*L.*) *flumensis*, *O.* (*L.*) *canius*, etc: in having a thick, strong shell and usually more acuminate dorsal valve. The exterior surface bears rather strong concentric lines of growth, and very fine, irregular, undulating, elevated striæ that suggest the surface of *O.* (*Westonia*) *ella*, when seen in a reflected light with a strong magnifier.

This little shell occurs abundantly, but good interiors have not been found. The main vascular sinuses appear to be submarginal in both valves, and the visceral area of the dorsal valve narrow, extending a little beyond the centre of the valve.

Formation and locality.—Middle Cambrian. Limestones of the Reagan formation, interbedded in the middle part of the Reagan greensand, 15 miles north of Fort Sill, one-half mile east of Canyon Creek, Wichita Mountains, Oklahoma Territory.

OBOLUS (LINGULELLA) PELIAS, new species.

This shell most nearly resembles *O.* (*L.*) *desideratus*. It differs in the squareness of the dorsal valve caused by the slightly curved sides and cardinal slopes. The ventral valve suggests the broader forms of *O.* (*L.*) *desideratus*, and the dorsal valve those of *O.* (*L.*) *mosia* and *O.* (*L.*) *winona* of the St. Croix sandstone.

The outer surface of the shell is marked by clearly defined concentric lines that are slightly irregular, and narrow, fine radiating undulations or costæ toward the frontal margins. When unusually well preserved, the surface also shows very fine, irregular concentric striæ between the concentric lines. The inner lamellæ of the shell are marked by fine radiating striæ and the inner surface by more or less numerous punctæ, very much as in *O.* (*L.*) *punctatus*. For its size the shell may be considered as relatively thin.

A single specimen of a ventral valve that is doubtfully referred to this species was collected 3 miles south of Antelope Springs, Utah, in limestone forming a spur of the House Range.

Formation and locality.—Middle Cambrian limestones of Fish Spring Range near north end; also a little south of the middle of the range, Utah.

The exact stratigraphic horizon of the limestones carrying this species is unknown. It is well up in the Middle Cambrian or in the Upper Cambrian.

OBOLUS (LINGULELLA) QUADRILATERALIS, new species.

General form rounded, quadrilateral; moderately convex. Surface marked by concentric lines and ridges of growth, with fine striæ between. The surface of the inner layers of the shell is shiny and marked by fine radiating striæ in addition to the concentric lines. The shell is rather thin; it is built up of several layers.

This species differs from other described species by its subquadrilateral outline. In this respect it may be compared with *O.* (*Westonia*) *chuarensis*, from which it differs in having a thinner shell and different surface markings.

Formation and locality.—Middle Cambrian. Coosa Valley shales, Cedarbluff, Cherokee County, Alabama.

OBOLUS (LINGULELLA) SEPTALIS, new species.

The dorsal valve is all that is known of this little shell. There are two specimens in the collections of the United States National Museum and three in the collection of Mr. Bryan E. Walker, of Toronto, Canada.

The general form of the valves is much like that of *O.* (*L.*) *rotundatus*. It is distinguished from the latter and other described species by the strong median ridge and septum of the dorsal valve. The outer surface is marked by concentric striæ and lines of growth and very fine irregular concentric striæ that give a minutely rough surface.

Formation and locality.—Middle Cambrian. Silicious shales, Mount Stephen, British Columbia.

OBOLUS (LINGULELLA) UPIS, new species.

This is a small, elongate shell of the group to which *O.* (*L.*) *ovus* belongs. It differs from the latter in being more elongate and in its marked surface characters, and from *O.* (*L.*) *collicia*, *O.* (*L.*) *flumensis*, *O.* (*L.*) *canius*, and allied forms, in having a thick, strong shell and highly characteristic exterior surface.

The shell is thick, the anterior portions being made up of numerous lamellæ oblique to the exterior surface, in this respect resembling some of the species of *Obolus* having thick shells. The exterior surface is marked by concentric lines of growth, with very fine, somewhat irregular striæ between them. These show very distinctly on the anterior portion of the shell. Farther back they become very irregular, giving a crenulated appearance to the striæ and lines of growth, and the surface looks as though it were formed of thin, imbricating scales or lamellæ.

The surface of *O.* (*L.*) *upis* suggests that of *O.* (*Westonia*) *euglyphus*, but I have been unable to find traces of the transverse lines characteristic of *Westonia.*

Formation and locality.—Middle Cambrian. One mile west of Cherokee, San Saba County, Texas.

OBOLUS (LINGULELLA) FUCHSI Redlich.

Lingulella fuchsi Redlich, Pal. Indica, new ser., I, 1899; Cambrian Fauna, Eastern Salt Range, p. 7, pl. I, figs. 10a–e.

In the collection received from Doctor Noetling I find that there occurs in association with *O.* (*L.*) *wanniecki* a small, elongate form that appears to be identical with *L. fuchsi* of Redlich. Doctor Redlich states that his *L. fuchsi* occurs in hard clay above the lower magnesian sandstones which rest on the shales containing *O.* (*L.*) *wanniecki.* If my identification of the species is correct, *O.* (*L.*) *wanniecki* has a greater vertical range, or there may have been some error in identification and in the labeling of the zone from which the original specimens were obtained. The identification of the species in the material before me is based on the form of the ventral valve, as shown by Doctor Redlich's figure 10c. Dorsal valves differ materially from his illustration; but in another specimen a little pit mentioned by Doctor Noetling is shown, also two ridges that leave a concave furrow in the central portion of the cast of the valve. These are the lines of the main vascular sinuses.

Formation and locality.—Middle Cambrian. Zone of *Hoeferia noetlingi*, in dark argillaceous shales, Khussak, Salt Range, India.

OBOLUS (LINGULELLA) WANNIECKI Redlich.

Lingulella wanniecki Redlich, Pal. Indica, new ser., I, 1899; Cambrian Fauna, Eastern Salt Range, p. 7, pl. I, figs. 9a–d.

General form broadly ovate, with the ventral valve obtusely accuminate and the dorsal valve rounded subtriangular; convexity moderate in the specimens embedded in argillaceous shales. There is considerable range of variation in the outline of the valves. The surface of the shell is marked by concentric lines of growth and very fine, closely undulating raised striæ that inosculate so as to give the surface a granulated appearance. This type of surface occurs on *O.* (*L.*) *isse* and *O.* (*L.*) *upis*. The anterior layers of the shell are marked by radiating and concentric striæ, and the interior of the shell has scattered punctæ in addition to the radiating and concentric striæ. The shell is relatively thick and formed of several layers or lamellæ in addition to the very thin, outer, ornamented layer.

The visceral area of the ventral valve is short, and the main vascular sinuses are about half way between the center of the shell and the lateral margins. In the dorsal valve the visceral area is well developed beyond the center of the shell, and the vascular sinuses are farther out proportionally than in the dorsal valve. The central and anterior lateral muscle scars are placed on an elevated central ridge, on each side of a sharp median septum.

Observations.—This very pretty little shell occurs in great numbers in the dark argillaceous shales with *Hoeferia noetlingi* Redlich. Doctor Redlich states that it is the only species of the genus in the collection sent to him. In the collections made by Dr. Fritz Noetling I find associated with *Hoeferia noetlingi*, *O.* (*L.*) *wanniecki*, *O.* (*L.*) *fuchsi*, "*Mobergia-Acrothele granulata*" Redlich; also specimens of a species of *Hyolithes* undescribed.

Among the American species of *Lingulella*, *O.* (*L.*) *wanniecki* may be compared in form with *O.* (*L.*) *zetus* and *O.* (*L.*) *oweni*. Its surface is much like that of *O.* (*L.*) *upis* and *O.* (*L.*) *orus*. It is distinct from all described species when its form and surface are taken into consideration, as there is no species with its subtriangular form that has its granulated surface.

Formation and locality.—Middle Cambrian. Zone of *Hoeferia noetlingi*. Dark argillaceous shales, Khussak, Salt Range, India. The formations containing this fauna are referred to the Middle Cambrian, as there is no evidence that the Cambrian fauna of India above the upper Annelid sandstone, as described by Dr. Fritz Noetling and Doctor Redlich, is older.

OBOLUS (LINGULEPIS) EROS, new species.

Ventral valve elongate with rostral slopes gradually converging so as to form an accuminate beak. Surface marked by fine concentric lines of growth and very fine, somewhat irregular, concentric striæ. Rather large scattered punctæ occur on the interior surface.

This species is represented by fragments and two broken ventral valves; these indicate a length for the ventral valve of from 7 to 10 mm. It is allied to *O.* (*Lingulepis*) *acuminatus weeksi* of the Middle Cambrian fauna of the Teton Mountains of Wyoming.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Three miles southwest of Yen Chang, Shantung, China.

Collected by Mr. Elliot Blackwelder of the Carnegie Institution expedition to China.

OBOLUS (LINGULEPIS) ROWEI, new species.

In outline and convexity the valves of this species are closely related to those of *O.* (*Lingulepis*) *acuminatus*. It differs from the latter and other described species by the strong, raised, concentric lines, with very imperfectly defined fine striæ between them.

The specific name is given in memory of Mr. R. B. Rowe, assistant geologist, who collected the material representing this species a short time before his death.

Formation and locality.—Middle Cambrian. Reddish-brown sandstone. Resting Springs, Inyo County, California.

OBOLUS (WESTONIA) ALANDENSIS, new species.

Lingula? sp. No. 2. *Lingulella?* sp. Nos. 3 and 5. Wiman, Bull. Geol. Institute, Upsula, No. 2, VI, 1903, Pt. 1; Studien Nordbaltische Silurgebiet, p. 52, pl. II, figs. 33, 35, 39.

This species is characterized by its broad form when compared with *O.* (*Westonia*) *bottnica*, *O.* (*Westonia*) *wimani*, and *O.* (*Westonia*) *baltica*. Its surface is marked by fine concentric lines of growth, with very fine, thread-like, concentric striæ between them. Under a strong, reflected light, almost microscopic, transverse, very irregular lines can be seen that give the surface somewhat the appearance of that of *O.* (*Westonia*) *ella*.

Formation and locality.—Middle? Cambrian. Gray, bituminous sandstone in drift bowlders on Åland and Biludden shores of Gefle Bay, Sweden.

For reference to geological horizon, see description of *O.* (*Westonia*) *bottnica*.

OBOLUS (WESTONIA) BALTICA, new species.

Lingulella? sp. No. 4 and 6. Wiman, Bull. Geol. Institute, Upsala, No. 2, VI, 1903, Pt. 1; Studien Nordbaltische Silurgebiet, p. 52, pl. II, figs. 34, 37, 38.

This species is characterized by its elongate form, with the sides of the dorsal valves regularly rounded from the back to the rounded frontal margin. The dorsal valves are also more regularly and strongly convex than in other species occurring in the Cambrian sandstones of Sweden. The outer surface is marked by concentric and radiating striæ, crossed obliquely by very fine, irregular transverse striæ. The latter are only to be seen with a strong magnifier and favorable light.

Formation and locality.—Middle? Cambrian. Gray, bituminous sandstone. Drift bowlders at Biludden, shore of Gefle Bay, and Skälstenarne. Also near Öfverby in the "Gemeinde of Jomala Åland."

OBOLUS (WESTONIA) BLACKWELDERI, new species.

General form elongate, with the width about one-half the length; front margin broadly rounded; sides slightly arched up to the lateral slopes which are quite straight in the ventral valve and curved toward the rounded posterior end of the dorsal valve; the beak of the ventral valve is pointed and marginal. The convexity of the valves is moderate, that of the dorsal apparently being the greater. Surface marked by concentric striæ and lines of growth which are crossed by irregular, fine, imbricating, more or less transverse lines; the transverse lines trend slightly backward toward the sides of the valves. A dorsal valve 8 mm. in length has a width of 5 mm.

Observations.—Nothing is known of the interior of the valves. When the shell is broken from the limestone, the outer surface usually adheres to the matrix. The best exteriors are those of shells on the surface of the layers. Of the known species of *Westonia*, *O.* (*W.*) *wimani* and *O.* (*W.*) *baltica* are most nearly related to *O.* (*W.*) *blackwelderi*. The latter is a larger shell and also less narrow proportionally where the gently arching sides pass into the postero-lateral slopes.

Formation and locality.—Middle Cambrian. Chang Hsia limestone. Two, and two and one-half miles south of Yen Chuang, Shantung, China.

Collected by Mr. Eliot Blackwelder of the Carnegie Institution expedition to China.

OBOLUS (WESTONIA) BOTTNICA Wiman.

Lingula bottnica WIMAN, Bull. Geol. Institute, Upsala, No. 2, VI, 1903, Pt. 1. Studien Nordbaltische Silurgebiet, p. 51, pl. II, figs. 40–44.

The description of *O.* (*Westonia*) *finlandensis* so closely applies to the description of this species that it is only necessary to point out the difference between the two.

The surface of *O.* (*Westonia*) *bottnica* has the same concentric and radiating lines, with the irregular transverse lines terminating at right angles to the margins, curving inward and backward in such a manner as to obliquely cross the radiating lines that extend from the umbo forward to the anterior and antero-lateral margins. The central scars of the dorsal valve are much further forward in *O.* (*Westonia*) *bottnica*.

Formation and locality.—Middle? Cambrian. Coarse grained, somewhat friable, glauconitic sandstone, drift bowlder No. 3 on Eggegrund Island, North Baltic.

Dr. Carl Wiman refers this species to the Olenellus sandstone series. The bowlder containing it also carried *Aparchites? anderssoni*, *Hipponicharior matthewi*, *Acretreta eggegrundensis*, *Kutorgina?? torellella lævigata*, and fragments referred to *Olenellus*. This fauna is essentially Middle Cambrian in its facies, and unless the fragments referred to *Olenellus* are indisputably of that genus, I am inclined to refer the bowlder and its contained fossils to the Middle Cambrian. The fact that *O.* (*Westonia*) *bottnica* is nearly identical with *O.* (*Westonia*) *finlandensis* of the *Paradoxides tessini* series of Finland, also points to the Middle Cambrian age of the fauna.

OBOLUS (WESTONIA) IPHIS, new species.

This shell differs from all other species of *Westonia* in having a more elongate and acuminate ventral valve, and in the presence of a marked mesial depression on the dorsal valve. The shell is rather thin and made up of several very thin layers or lamellæ. The outer surface is marked by fine radiating striæ, concentric striæ, and lines of growth, and fine more or less undulating, transverse lines that cross both the radiating and concentric lines. The transverse lines appear to be the edges of slightly elevated imbricating lamellæ of the shell.

Formation and locality.—Upper Cambrian and Ordovician. Lower Ordovician Pogonip formation, Hamburg Ridge; also near the Bullwacker Mine, in the Upper Cambrian Eureka District, Nevada.

OBOLUS (WESTONIA) THEMIS, new species.

General form subsemicircular, with the ventral valve subacuminate and the dorsal valve broadly ovate in outline. Valves rather strongly convex. Surface of the shell marked by strong concentric lines of growth with finer intermediate striæ; in addition there are very fine, irregular, raised, more or less transverse striæ that inosculate, forming a minutely papillose or granular surface much like that of *O.* (*W.*) *ella*. It often occurs that the outer surface has been removed by attrition in the sand, so that the shell has a smooth, polished surface. Owing to the condition of preservation, the markings of the inner layers are not preserved. The shell is strong and thick in advance of the center. It is made up of the thin, outer surface layer and several inner layers, as lamellæ, in the posterior portions that are slightly oblique to the outer surface. After the shell has attained a size of 2 or 3 mm., the lamellæ are more oblique to the outer surface and form a thick, strong shell, the outer edges of which often produce a rather rough surface.

The largest ventral valve in the collection has a length and breadth of 10 mm.; a dorsal valve 10 mm. in length has a width of 11 mm. The only interior portion of the shell known is on a fragmentary ventral valve, in which the visceral area does not reach the center, and the main vascular sinuses are about halfway between the center and the lateral margins of the valve.

Observations.—The general form and character of the shell is much like that of *O. loperi*. It differs from the latter in surface characters.

Formation and locality.—Middle Cambrian. Solomon Formation, 235 feet above Tonto sandstone, Grand View Trail, southern side of Grand Canyon, Arizona.

OBOLUS (WESTONIA) WIMANI, new species.

Lingula ? sp. Nos. 1 and 2. *Lingulella ?* sp. No. 7, WIMAN, Bull. Geol. Institute, Upsala, No. 2, VI, 1903, Pt. 1; Studien Nordbaltische Silurgebiet, pp. 51, 52; pl. II; figs. 30, 31, 32, 36.

The general form of this species is not unlike that of *O.* (*Westonia*) *bottnica*. The cardinal slopes of the ventral valve are more rounded, which makes the valve broader near the center. All of the specimens are also smaller. The surface markings are of the same character as those of *O.* (*Lingulella*) *finlandensis* and *O.* (*Westonia*) *bottnica*.

It is not improbable that with the discovery of a large series of specimens the three species may be combined, or *O.* (*Westonia*) *bottnica* and *O.* (*Westonia*) *wimani* placed as varieties of *O.* (*Westonia*) *finlandensis*.

The species is named after Dr. Carl Wiman.

Formation and locality.—Middle ? Cambrian. Fine gray sandstone, drift bowlders at Biludden, shore of Gefle Bay, Sweden. For reference to geological horizon refer to description of *O.* (*Westonia*) *bottnica*.